Volume 2
Number 2
1977

entomon

PUBLISHED BY

THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM,

TRIVANDRUM, INDIA 695581

ENTOMON

Entomon is a half-yearly journal of the Association for Advancement of Entomology issued in June and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to the Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695581.

SUBSCRIPTION RATES

Annual subscription for institutions: Rs 80/– (in India); $ 30/– (abroad)
individuals: Rs 50/– ,, ; $ 20/– ,,

ADVERTISEMENT RATES

Full page Rs 200/–; half page Rs 125/–; quarter page Rs 75/–.

Address all business correspondence to the Secretary-Treasurer of the Association.

---

1. **All remittances to the journal or the Association should be sent to the Secretary-Treasurer of the Association.**
2. **Cheques should be A/c payee in favour of the Association for Advancement of Entomology.**
3. **Requests for replacement copies of ENOMON in lieu of numbers lost in transit, should reach the Secretary – Treasurer not later than three months (nine months for requests from abroad) after the date of issue of the number.**

ENTOMON

Volume 2 Number 2 1977

CONTENTS

BRIEF COMMUNICATIONS

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 115 *to* 119

STERILIZING POTENCY OF THIOTEPA ON THE ADULT RED COTTON BUG, *DYSDERCUS KOENIGII*

N. GOVINDAN & M. K. K. PILLAI

Department of Zoology, University of Delhi, Delhi
India 110007

(*Received* 17 *September* 1977)

A laboratory investigation on the toxicity and sterilizing effect of thiotepa in the red cotton bug, *Dysdercus koenigii* is reported here. Thiotepa when applied topically or by injection to newly emerged adults caused complete sterility in both the sexes. Sterilizing dose of thiotepa was proved to be not toxic to the adults. Treatment of higher doses in adult females significantly reduced fecundity and weight of the eggs.

INTRODUCTION

Aziridinyl compounds are known to be the most effective chemosterilants for insects (BORKOVEC, 1966). There are reports that the red cotton bug, *Dysdercus koenigii* could be sterilized by treating the immature stages with chemosterilants such as tepa and apholate (MUSTAFA & NAIDU, 1964; ISLAM, 1971; SEHGAL & MAHESWARI, 1974). Thiotepa (tris (1–aziridinyl) phosphine sulphide), a sulphur analogue of tepa is known to be a very potent sterilant for many species of insects (BORKOVEC, 1966). Therefore, investigations were undertaken to evaluate the sterilizing effects of thiotepa in the adult of *D. koenigii* by different methods of application. In addition, the effects of thiotepa on the fecundity of females and the egg weights were also studied. The results are discussed in this paper.

MATERIALS AND METHODS

A colony of *D. koen'gii* was established in our laboratory since 1974 and maintained at 26±1°C (BHARGAVA & PILLAI, 1976). Stock solutions of thiotepa were prepared in acetone for topical application, and in cockroach Ringer solution for injection. Adults of *D. koenigii* on emergence were sexed and isolated in separate jars. Twelve hour-old adults were treated topically by applying 4μl of thiotepa solution dorsally between the thorax and abdomen by means of a micro applicator. Similarly adults were injected 4μl of thiotepa in Ringer solution through the femur of the third leg by means of a Hamilton microsyringe. Control insects were either treated with acetone or Ringer solution. After treatment 5 females and 5 males were isolated and were put into separate jars and allowed to mate. Four different crosses (a) treated female × treated male; (b) treated female × normal male; (c) normal female × treated male and (d) normal female × normal male were made. Mortaltity counts were made once in every 24 hr for a period of 10 days and the corrected percentage mortality was calculated according to Abbott's formula (ABBOTT, 1925). The eggs laid by the females for the above period in each cross were collected separately and scrored. They were incubated under the rearing conditions to determine the percentage hatch. Each cross was replicated five times.

In order to achieve maximum reduction in fecundity the females were treated with 4 to 15μg of thiotepa per insect either by topical application or by injection. The treated females were crossed with normal males and the oviposition rate per female was scored for 10 days. Samples of 50 eggs were collected at random from each batch of eggs within 12 hrs of ovipostion and egg weights were recorded using a semimicro Mettler balance. The experiments were replicated 4 times with parallel controls.

RESULTS

Thiotepa did not cause any appreciable mortality in the adults (Table 1). A dose of 4μg of thiotepa treated topically or by injection caused less than 10% mortality. The males appeared to be more susceptible than the females. Injection of 2 to 4μg thiotepa was more toxic to the adults unlike corresponding topical treatments.

When topical application was increased from 0.5 to 4μg per insect the sterility steadity increased from 33% to 100% (Table 2). The sterility was more when treated males were crossed to normal females than in reciprocal crosses. However, a dose of 4μg thiotepa caused 100% sterility in both the sexes. When thiotepa was administered by injection the sterility increased from 52 to 100% (Table 2) as the doses were raised from 0.5 to 4μg per insect. Males were more susceptible to the sterilizing effect of thiotepa than the females. As in topical application, 4μg thiotepa when injected produced 100% sterility.

After treatment of females with higher doses, of thiotepa by topical application the fecundity gradually declined and complete inhibition of oviposition was observed with a dose of 15μg per female (Table 3). In general, the fecundity was more reduced in the second oviposition. In topical application the fecundity in both the batches of all the treatments was less than that of the control ($P<0.01$). When thiotepa was injected, a similar significant reduction in oviposition was observed ($P<0.01$). There was no significant difference in the number of eggs laid between the first and second ovipositions of the normal female. However, the number of eggs laid by the treated females in the first oviposition was significantly more than that of the second oviposition ($P<0.01$), with the exception of the treatment of 8μg of thiotepa by injection. Topical application or injection of 4μg thiotepa did not cause any reduction in the egg weight as compared to the control of the first batch of eggs (Table 3) while all the other doses caused significant reduction in egg weights in the first and second batches of eggs ($P<0.01$).

It is evident from the data that non-toxic doses of thiotepa induced high sterility in both the sexes of *D. koenigii*. The

TABLE 1. Toxicity of thiotepa to adults of *D. koenigii*.

Dose (μg/insect)	Corrected mortality (%)			
	Topical application		Injection	
	Male	Female	Male	Female
0.5	0	0	0	0
1	0	0	0	0
2	0	0	8.3	0
3	0	4.2	4.2	4.2
4	8.3	4.2	8.3	4.2
Control	0	0	0	0

TABLE 2. Effect of thiotepa on the fecundity and hatchability of eggs of *D. koenigii*.

Dose (μg/insect)	Sex treated	Topical application		Injection	
		No. eggs laid/ ♀	Egg hatch (%)	No. eggs laid/ ♀	Egg hatch (%)
0.5	F, M	154.2	66.1	163.6	47.0
	M	171.0	60.3	182.4	65.6
	F	175.2	77.2	173.6	82.1
1	F, M	164.0	38.6	165.8	44.5
	M	159.8	44.7	173.2	59.2
	F	167.4	65.8	191.0	72.0
2	F, M	183.4	32.3	180.0	28.8
	M	177.8	33.1	198.8	33.8
	F	155.2	44.4	172.6	39.8
3	F, M	166.8	20.0	184.0	13.2
	M	166.4	22.9	176.8	17.4
	F	180.0	27.7	163.8	24.3
4	F, M	173.4	0	172.4	0
	M	169.2	0	172.4	0
	F	169.2	0	168.8	0
Control	None	180.2	88.8	168.0	90.5

TABLE 3. Effect of thiotepa on the fecundity (number of eggs laid/female) and egg weight of *D. koenigii*.

Dose (μg/ ♀)	Topical application		Injection	
	I Batch	II Batch	I Batch	II Batch
4	118.6±5.0 (25.2±0.5)	99.6±9.8 (23.1±0.3)	113.1±5.9 (26.3±0.4)	93.8±8.2 (25.8±0.6)
6	117.2±6.6 (21.8±0.2)	95.8±9.7 (22.8±0.3)	110.0±8.5 (24.4±0.2)	84.0±7.3 (24.6±0.3)
8	106.0±8.6 (21.2±0.7)	94.4±5.3 (22.0±0.5)	84.8±4.4 (23.0±0.5)	84.6±11.1 (21.6±0.6)
10	85.2±3.0 (22.3±0.4)	58.6±8.2 (20.4±0.7)	80.4±8.2 (23.8±1.0)	67.8±9.8 (20.1±0.6)
15	0	0	0	0
Control	130.4±5.2 (25.8±0.4)	115.6±7.2 (27.4±0.4)	118.0±7.2 (27.8±0.4)	111.6±11.8 (27.0±0.6)

Figures in parantheses refer to weight of eggs in mg/50 eggs.
Batch refers to oviposition.

difference observed in the mortality rate between the two methods of application could be attributed to the mode of administration as the chemical could reach the target faster in injection than when applied topically. Similarly, CHAMBERLAIN (1962) observed that apholate where applied by dusting, immersion, topical application or by feeding showed variations in mortality and sterility.

Injection of lower doses of thiotepa was more effective in inducing sterility in *D. koenigii* as compared to corresponding topical treatments. SEHGAL & MAHESWARI (1974) reported that *D. koenigii* could be sterilized by the application of low doses of tepa when applied to immature stage. However, it is evident from the present studies that higher doses of thiotepa are required to cause complete sterility in adults. Similarly *D. cingulatus* required higher doses of tepa and apholate to induce 100% sterility (MUSTAFA & NAIDU, 1964; ISLAM, 1971).

The present data also indicate that reduction of fecundity in *D. koenigii* could be achieved by using higher doses of thiotepa. Many aziridines are known to reduce fecundity of the female insect by interfering with ovarian growth and oocyte development (MORGAN & LABRECQUE, 1964; LA CHANCE, 1967). Treatment of *D. cingulatus* with tepa or metepa caused degeneration of oocyte and inhibition of ovarian growth (SUKUMAR & NAIDU, 1973; JALAJA & PRABHU, 1976). In general, the number of eggs laid in the second oviposition by *D. koenigii* treated with thiotepa was less than that of the first oviposition. Similar reduction in the number of ovarioles in successive gonotrophic cycles in mosquitoes treated with chemosterilants is attributed to their carcinostatic and mutagenic effects on the somatic cells of the ovary (BERTRAM, 1963).

The higher doses of thiotepa also caused significant reduction in egg weight as compared to the control. Alkylating agents such as aziridines react with proteins and nucleic acids of rapidly growing tissues and thereby inhibit or alter their growth (ALEXANDER, 1960). Thiotepa inhibited nucleic acid, and protein synthesis in thiotepa treated *D. koenigii* (unpublished data). Reduced protein synthesis seems to account for the reduction in egg weights of the treated insects. It may also be due to the non-availability of nutrients at the site of developing eggs (TURNER, 1972).

Acknowledgements:— The authors wish to thank Dr. A. B. BORKOVEC, USDA, Beltsville, Maryland, U.S.A, for the supply of thiotepa.

REFERENCES

ABBOTT, W. S. (1925) A method for computing effectiveness of an insecticide. *J. econ. Ent.*, **18:** 265–267.

ALEXANDER, P. (1960) Radiation-imitating chemicals. *Scient. Am.*, **202** : 99–108.

BERTRAM, D. S. (1963) Observations on the chemosterilant effects of an alkylating agent thiotepa, on wild caught *Anopheles gambiae* Var. *Melas* (Thea) in Gambia, West Africa, and on laboratory bred *A. g. gambiae* GILES and *Aedes aegypti* (L.). *Trans. R. Soc. trop. Med. Hyg.*, **57** : 322–335.

BHARGAVA, S. & M. K. K. PILLAI (1976) Haematological effects of apholate in the Red cotton bug, *Dysdercus koenigii*. *Entomologia exp. & appl.*, **20** : 218–274.

BORKOVEC, A. B. (1966) Insect chemisterilants. *Adv. Pest Control Res.*, **7** : 1–143.

CHAMBERLAIN, W. F. (1962) Chemical sterilization of the screwworm. *J. econ. Ent.*, **55** : 240–248.

ISLAM, A. (1971) Chemical sterilization of *Dysdercus cingulatus* FABR. *Botyu-Kagaku*, **36** : 101–104.

JALAJA, M. & V. K. K. PRABHU (1976) Effect of the chemosterilants apholate and metepa on the ovaries of the red cotton bug, *Dysdercus cingulatus* FABR. (Insecta, Heteroptea, Pyrrhocoridae). *Entomon*, **1** : 43–53.

LA CHANCE, L. E. (1967) The induction of dominant lethal mutations in insects by ionizing radiation and chemicals as related to the sterile-male technique of insect control, 617–650, *in*: *Genetics of Insect Vectors of Diseases*. (ed. WRIGHT, J. W. & R. PAL) Elsevier, Amsterdam.

MORGAN, P. B. & G. C. LABREQUE (1964) Effects of tepa and metepa on the ovarian development of house flies. *J. econ. Ent.*, **55** : 626–628.

MUSTAFA, M. & M. B. NAIDU (1964) Chemical sterilization of *Dysdercus cingulatus* F. *Ind. J. Exp. Biol.*, **2** : 55–56.

SEHGAL, S. S. & S. C. MAHESHWARI (1974) Effects of nymphal treatment with tepa on the reproduction of *Dysdercus koenigii*. *Curr. Sci.*, **43** : 334–338.

SUKUMAR, K. & M. B. NAIDU (1973) Inhibition of ovarian growth by tepa in *Dysdercus cingulatus*. *J. econ. Ent.*, **66** : 20–22.

TURNER, R. B. (1972) Design of insect chemosterilants, 339–412, *in: Drug Design*, **3** (ed ARIENS, E. J.) Academic Press, NY.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 121 *to* 127

EFFECT OF X-IRRADIATION ON PHOSPHORYLASE ACTIVITY IN THE COCKROACH, *PERIPLANETA AMERICANA*

S. VIJAYALAKSHMI, T. PAVAN KUMAR, G. RAJARAMI REDDY & K. SASIRA BABU
Department of Zoology, S. V. University, Tirupati, India 517502

(*Received* 2 *August* 1977)

During early hours of post-irradiation, elevation in phosphorylases 'a' and 'ab' and a subsequent fall in enzyme levels were noticed in the nervous system and coxal muscle of the cockroach under varied doses of X-irradiation. Sublethal dose exposure caused early increase and subsequent normalization in the enzyme levels. Under lethal dose a rapid elevation in enzyme level during early hours, and subsequent irreversible inhibition at later periods were noticed. Seven days after exposure to lethal dose, the animals showed acute radiation sickness, finally resulting in death. These changes suggested derangement in oxidative phosphorylation after exposure to ionizing radiation. The degree of disorder was dose dependent.

INTRODUCTION

Studies of SAVITSKII & LITOVCHENKO (1976) and VASITENKO (1976) showed increased ATPase activity and decreased oxidative phosphorylation after whole body X-irradiation of mice. Ionizing radiation was also demonstrated to produce disorders in respiration and oxidative phosphorylation in rats and rabbits (KORZHOV & KHRIPTA, 1970; ELKINA & LIBINZON, 1971; MALOVICHKO & SHAMRAI, 1971; SUKHANOVA & DOKSHINA, 1973). Mitochondrial deformation due to whole body X-ray exposure resulted in the reduction of oxidative phosphorylation (ALEXANDER *et al.*, 1972). KORSTROMSKAYA (1972) also reported radiation induced changes in energy metabolism in phytogenesis of invertebrates. The present study depicts the effects of sublethal and lethal doses of X-irradiation on phosphorylase activity in nervous system and coxal muscle of the cockroach, *Periplaneta americana*.

MATERIALS AND METHODS

Philips generator model DA-1 PW 1009/30 NR D 794 (Holland, Netherlands) with tungston (W) target for emitting spectrum of continuous white radiation was used for X-irradiation of the animals. The exposure rate was measured in air at the centre of the body with a Victoreen Radcon Chamber Model 50 (175 R/minute).

Two adult male cockroaches were taken each time in a perforated glass tube and fixed to a stand at an equidistance of 13.5 cm on both sides from the centre of a rotating table. In this position, the whole-body of the animal was irradiated singly from the dorsal side with required doses aerobically, as described by CASARETT (1968). After exposure the animals were kept in temperature and humidity controlled room (26 ± 2°C, 80 ± 5%) and were fed *ad libitum* upto the time of sacrifice.

Nervous system (NS) and coxal muscle (CM) of irradiated and non-irradiated (control) animals were isolated in ice-cold condition during specific post-irradiation periods. Tissue homogenates prepared in ice-cold tris-sucrose (0.25M) solution were used for the assay of enzyme activity.

Phosphorylase ('a' and 'ab') levels were determined in the direction of glycogen synthesis as described by CORI *et al.*, (1955). Levels of inorganic phosphate were determined by the method of FISKE & SUBBA ROW (1925) and proteins were estimated using the method of LOWRY *et al.* (1951).

Determination of LD_{50} was done as per the method of DRASTADT-BEHREN (1975). In the text 1/3 of LD_{50} dose was designated as sublethal and LD_{50} as lethal doses.

RESULTS AND DISCUSSION

From Table 1 it is evident that the levels of phosphorylase ('a' and 'ab') activity in the

NS and CM were elevated above the control values (4 hrs after exposure) under varied doses of X-irradiation. Maximum effect in both the tissues was observed with a dose of 15,000 R for phosphorylase 'a' and 10,000 R for phosphorylase 'ab' levels (Table 1). Above these dose ranges a fall in the enzyme level was noticed. These results confirm the "Enzyme release hypothesis" during early hours after irradiation of BACQ & ALEXANDER (1966) and STRAZHEVSKAYA (1975).

Sublethal dose (3,500 R) was elevatory on phosphorylase ('a' and 'ab') activity levels upto 1 day after exposure, in NS and CM of *Periplaneta* (Table 2). On 3rd day, an insignificant alteration was noticed and the enzyme activity was almost equal to the control values. With progression in post-irradiation period, though the enzyme activity exhibited fall over control, there was a revival tendency in both the tissues. These results indicate the presence of a progressive repair mechanism following irradiation at subcellular levels as reported by ALEXANDER *et al.* (1972). Similar renovation tendency of glycolytic enzymes and other oxidative enzymes were reported under mild dose exposures (BACQ & ALEXANDER, 1966; CASARETT, 1968).

From Table 3 it is observed that the enzyme activity significantly ($P < 0.001$) increased above the control level in both the tissues immediately (2 hrs) after irradiation with lethal dose (10,500 R). Thereafter, the level of activity of both phosphorylase 'a' and 'ab' dropped below the control values, and the maximum fall was registered on 7th day of post-irradiation period (Table 3). The sharp rise in phosphorylase activity during early hours of lethal dose irradiation appears to be due to impaired functional capacity of mitochondria of the cell. BACQ & ALEXANDER (1966) and STRAZHEVSKAYA (1975) suggested that the rise in enzyme level might be due to increased permeability of enzyme to mitochondria or cell membrane. It can also be suggested that radiation induces rapid synthesis of either enzyme or enzyme systems at cellular level in order to cope with the energy demands of the cell under imposed conditions of metabolic stress. Hence, the process of glycolysis may be more operative due to high phosphorylase activity which may result in enhanced energy metabolism. This enhanced phosphorylase activity is also in corroboration with the suggestion of "Enzyme release hypothesis" of BACQ & ALEXANDER (1966) and VIJAYALAKSHMI (1977) during initial periods of post-irradiation.

The observed drop in enzyme activity during later periods of lethal dose exposure and concomitant increase in glycogen content (unpublished data) may be attributed to the inactivation of oxidative phosphorylation and accumulation of glycogen in the tissues of *Periplaneta*. Similar fall in oxidative phosphorylation was reported by VASITENKO (1976) and SAVITSKII & LITOVCHENKO (1976) in rats and mice. Loss in phosphorylase and succinate dehydrogenase activity levels and rise in ATPase activity indicate deterioration of mitochondrial content (VASITENKO, 1976).

It is also probable that radiotoxins like hydrogen peroxide, hydrogen sulphide, ammonia etc., are released in the tissues due to irradiation (HUTCHINSON, 1957; BACQ & ALEXANDER, 1966). These radiotoxins might play a significant role in the inhibition of phosphorylase activity. This factor is suggestive of the influence of radiation on several facets of energy metabolism of the animal.

TABLE 1. X-ray dose effect on phosphorylase activity in *Periplaneta*. Enzyme activity is expressed as μmoles of Pi formed/mg protein/hour.

			Radiation dose (R)						
			Normal	500	1000	5,000	10,000	15,000	20,000
Nervous system									
Phosphorylase	'a'	level	17.03	18.10	18.79	20.81	22.53	24.15	20.56
		SD	±1.12 (NS)	±1.32 (NS)	±1.41 (NS)	±0.96 (S)	±0.87 (S)	±0.84 (S)	±1.02 (S)
		PDN	..	6.285	10.34	22.20	32.30	41.82	20.73
Phosphorylase	'ab'	level	50.79	52.60	54.46	59.65	66.08	61.37	57.52
		SD	±2.04 (NS)	±1.18 (NS)	±1.07 (NS)	±2.16 (HS)	±1.84 (S)	±2.13 (S)	±1.26 (S)
		PDN	..	3.56	7.23	17.44	30.09	20.87	13.25
Coxal Muscle									
Phosphorylase	'a'	level	13.27	13.31	14.16	15.52	17.38	18.64	15.49
		SD	±0.88 (NS)	±0.49 (NS)	±0.78 (NS)	±1.05 (NS)	±0.85 (S)	±0.62 (S)	±0.47 (S)
		PDN	..	0.278	6.24	15.77	28.80	40.24	15.56
Phosphorylase	'ab'	level	38.26	39.18	40.57	45.13	48.32	44.50	42.11
		SD	±0.68 (NS)	±0.79 (NS)	±0.98 (NS)	±1.15 (S)	±1.03 (S)	±0.62 (S)	±0.74 (S)
		PDN	..	2.14	6.04	17.96	26.28	13.70	10.07

SD — Standard deviation of five individual observations
HS — Highly significant
S — Significant
NS — Not significant
PDN — Per cent deviation over normal

TABLE 2. Post-irradiation effect on phosphorylase activity in the tissues of *Periplaneta* under sublethal dose exposures. Activity is expressed as μmoles of Pi formed/mg protein/hour.

			Post-irradiation time						
			Normal	2 hrs	1 day	3 days	5 days	7 days	9 days
Nervous system									
Phosphorylase	'a'	level	17.03	20.46	21.05	16.92	15.76	16.29	14.85
		SD	±1.12 (S)	±0.72 (NS)	±0.58 (S)	±1.06 (NS)	±0.48 (NS)	±0.66 (NS)	±0.54 (S)
		PDN	..	+20.15	+23.61	—0.646	—7.46	—4.35	—12.80
Phosphorylase	'ab'	level	50.79	62.05	65.86	55.97	51.64	47.59	47.03
		SD	±2.04 (HS)	±2.46 (S)	±0.97 (S)	±1.52 (S)	±1.32 (S)	±1.94 (NS)	±0.78 (NS)
		PDN	..	+22.17	+29.65	+10.21	+1.67	—6.3	—7.41
Coxal muscle									
Phosphorylase	'a'	level	13.27	14.68	16.22	13.66	11.83	11.02	12.18
		SD	±0.88 (NS)	±0.56 (S)	±1.04 (S)	±0.59 (NS)	±0.72 (NS)	±0.41 (NS)	±0.95 (NS)
		PDN	..	+10.63	+21.47	+2.94	—10.85	—16.95	—8.02
Phosphorylase	'ab'	level	38.26	42.58	46.14	39.20	35.76	34.88	35.97
		SD	±0.68 (S)	±0.92 (S)	±1.36 (S)	±1.15 (S)	±0.87 (NS)	±0.65 (NS)	±0.59 (S)
		PDN	..	+11.29	+20.58	+2.46	—6.53	—8.83	—5.98

SD — Standard deviation of five individual observations
HS — Highly significant
S — Significant
NS — Not significant
PDN — Per cent deviation over normal
\+ Increment
— Decrement

TABLE 3. Post-irradiation effects on phophorylase activity in the tissues of *Periplaneta* under lethal dose exposure. Activity is expressed as μmoles of Pi formed/mg protein/hr.

			Post-irradiation time					
			Normal	2 hrs	1 day	3 days	5 days	7 days
Nervous system								
Phosphorylase	'a'	level	17.03	25.46	16.35	14.52	12.58	11.68
		SD	±1.12 (NS)	±1.35 (S)	±2.97 (NS)	±1.08 (S)	±0.93 (NS)	±0.78 (S)
		PDN	..	+49.51	−3.99	−14.74	−26.14	−31.43
Phosphorylase	'ab'	level	50.79	73.68	51.85	46.77	43.49	37.06
		SD	±2.04 (HS)	±2.57 (HS)	±1.74 (S)	±1.26 (S)	±0.96 (S)	±1.52 (HS)
		PDN	..	+34.98	+2.09	−7.91	−14.37	−27.04
Coxal muscle								
Phosphorylase	'a'	level	13.27	17.53	13.49	11.65	10.79	9.06
		SD	±0.88 (S)	±1.18 (S)	±0.95 (S)	±0.76 (NS)	±0.82 (NS)	±0.49 (S)
		PDN	..	+32.11	+1.66	−12.21	−18.69	−31.74
Phosphorylase	'ab'	level	38.26	49.74	42.16	36.20	32.38	28.67
		SD	±0.68 (HS)	±1.36 (S)	±1.75 (S)	±1.16 (S)	±1.44 (S)	±1.68 (HS)
		PDN	..	+30.00	+10.20	−5.38	−15.37	−25.06

SD — Standard deviation of five individual observtions
HS — Highly significant
S — Significant
NS — Not significant
PDN — Per cent deviation over normal
\+ Increment
— Decrement

Since reduced glycolytic activity results in decreased ATP production, many physiological functions might be slowed down, as a result of which the animal may enter into a pathological state. Thus, the degree of lethality caused to the animal is a function of dose and post-irradiation time interval, as also suggested by CASARETT (1968).

The irreversible drop in phosphorylase activity with lethal dose (Table 3) may be due to progressive degeneration and deformation of mitochondria (CHERNOGUZOV & PIKULEV, 1971). As oxidative phosphorylation and carbohydrate metabolizing cycles are mostly confined to mitochondria (HARPER, 1973), it is likely that mitochondrial destruction and autolytic deformation could be one of the causative factors that diminish glycolysis. As phosphorylase occupies a central role in the process of glycolysis of the cell, even an insignificant alteration in its activity may disturb the harmony of biochemical processes of the organism. Hence, it is apparent that lethal dose of X-irradiation produced irreversible changes in the energy metabolism besides severe cellular damage to the system (STRAZHEVSKAYA, 1975).

Acknowledgement:– The financial assistance rendered by UGC (to SV) and CSIR (to TPK and and GRR) is acknowledged.

REFERENCES

ALEXANDER, K. G. & A. S. ADYAR (1972) Site of impairment of oxidative phosphorylation in irradiated rats. *Biochem. Biophys. Acta*, **283**: 206–216.

BACQ, Z. M. & P. ALEXANDER (1966) Biochemical mechanisms for cellular effects : The enzyme release hypothesis, 263–279; & Pathological biochemistry of irradiated living organisms, 311–368, *in : Fundamentals of Radiation Biology*. E. L. B. edition II, Pergaman Press, New York.

CASARETT, A. P. (1968) Radiation detection and dosimetry: exposure of biological systems, 53–57, *in : Radiation Biology*, Prentice Hall Inc., Engelwood Cliffs, New Jersey.

CHERNOGUZOV, V. M. & A. T. PIKULEV (1971) Effect of X-irradiation on AAT activity of brain mitochondra. *Dokl. Akad. Nauk Belorussk. SSR*, **14** : 367–369.

CORI, G. T., B. ILLINGWORTH & P. J. KELLER (1955) Enzymes of carbohydrate metabolism : Muscle phosphorylase, 200–205, *in : Methods in Enzymology*, *Vol.* 1. (eds. COLOWICK., S. P. & N. O. KAPLAN) Academic Press Inc., New York.

DRASTADT-BEHREN (1975) *in vitro* antigen-antibody reactions: Cytotoxicity and neutralization: Neutralization of toxins, 251–266, *in : Immunology & Serology*, 3rd ed. (ed. CARPENTER, P. L.), W. B. SAUNDERS Co., Philadelphia.

ELKINA, N. I. & R. E. LIBINZON (1971) Activity of phosphorylation ezymes of thymidine and thymidilic acid in the bone marrow of irradiated rabbits. *Radiobiologiya*, **11** : 22–27.

FISKE, C. H. & Y. SUBBA ROW (1925) Blood Analysis: Determination of inorganic phosphate, 1113–1115, *in : Hawk's Physiological Chemistry*. 14th ed. (ed. OSER, B. L.) McGraw-Hill Book Co., New York.

HARPER, H. A. (1973) Metabolism of carbohyhydrate: Phosphorylase activation and inactivation, 248–250, *in : Physiological Chemistry-Review*, 12th ed. Lange Medical Publications, Los Altos.

HUTCHINSON, F. A. (1957) Effect of radiation on macromolecules, 157–212, *in : Fundamentals of Radiation Biology*. E. L. B. edition II, (eds. BACQ, Z. M. & P. ALEXANDER) Pergamon Press, New York.

KORSTROMSKAYA, V. A. (1972) Radiation induced changes in the oxidative phosphorylation and catalase activity in phytogenesis of invertebrates. *Radiobiologiya*, **12** : 437–444.

KORZHOV, V. I. & F. P. KHRIPTA (1970) Respiration and oxidative phosphorylation of rat liver mitochondria during administration of indicator quantities of P_{32} and Au_{198} to the rat. *Med. Radiol.*, **15** : 85–86.

LOWRY, O. H., N. J. ROSENBROUGH, A. L. FARR & R. J. RANDALL (1951) Protein measurement with Folin-phenol reagent. *J. biol. Chem.*, **193**: 265–275.

MALOVICHKO, I. I. & A. E. SHAMRAI (1971) Oxidative phosphorylation in spleen mitochondraia during treatment of acute radiation sickness. *Radiobiologiya*, **10** : 590–592.

SAVITSKII, I. V. & I. N. LITOVCHENKO (1976) Oxidative phosphorylation and adenyl nucleotides in the liver of rats wih radiation sickness. *Radiobiologiya*, **16** : 16-20.

SUKHANOVA, G. A. & G. A. DOKSHINA (1973) Depressive effect of aurantin on oxidative phosphorylation of liver mitochondria during irradiation. *Radiobiologiya*, **13** : 433–457.

STRAZHEVSKAYA, N. B. (1975) Radiation effects on enzymes and chemistry of radiotoxins, 218, *in: Molecular Radiobilogy* VI, Academic Press Inc., New York.

VASITENKO YU, K. (1976) Characteristics of the biological effect of super high frequency electromagnetic radiations. *Izv. sev Kavk Nauchn. Tsentra Vyssh Ssk Este Nauki*, **3** : 61–64.

VIJAYALAKSHKI, S. (1977) Doctoral Dissertation S. V. University, Tirupati (India).

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 129 *to* 131

CHROMOSOME COMPLEMENT OF THE GRASSHOPPER *SCELIMENA HARPAGO* SERV. (TETRIGIDAE: ORTHOPTERA)

N. N. GODBOLE & S. Y. PARANJAPE[1]
Zoology Department, Maharashtra Association for the Cultivation of Science-Research Institue, Poona, India 411004

(*Received* 24 *May* 1977)

Chromosome complement of *Scelimena harpago* (Orthoptera, Insecta) is reported. The Chromosome number is 13 (12AA + X) in male and 14 (12 AA + XX) in female. All the chromosomes are acrocentric. The X chromosome is of the size of small autosomes and hence of the "Tetrix type". The species shows a remarkable similarity in chromosome number and in acrocentric nature of all chromosomes to other species of this family studied so far.

INTRODUCTION

Several studies on chromosome structure, chromosomal polymorphism, chromosome behaviour, sex-chromosomes etc. have been carried out on different Orthoptera (WHITE 1951). Most of these deal with the species of Acrididae, Tettigonidae, Gryllidae and Gryllotalpidae. Family Tetrigidae is relatively less investigated cytologically. So far only thirteen species of this family have been studied from this point of view all over the world (HENDERSON, 1961). However, no information is available on the cytology of Indian species of this family. The chromosome complement of *Scelimena harpago* described here forms the first report on the Indian members of the family.

MATERIALS AND METHODS

Male and female specimens were collected from the ponds, pools and tanks before their breeding season, which begins with the monsoon. In addition, specimens from cultures maintained in the laboratory were also used for the cytological studies. Gonads were dissected out in insect Ringer solution and fat, trachea and other adhering tissues were removed. The cleaned gonad was then transferred to a centrifuge tube containing 0.075 M KCl for 20 min. The gonadal tissue was dissociated by gentle aspiration using a Pasture pipette. The suspension was then centrifuged at 500 rpm for 10 minutes. The supernatant was discarded and the pellet was fixed in 3 : 1 methanol-acetic acid. After one more change of the fixative, the cells were finally suspended in about 0.2—0.3 ml of the fixative. The slides were prepared by air-drying technique, dried overnight and then stained with Giemsa at pH 6.8. Some slides were stained for heterochromatin by the method described by BOSMAN & SCHABERG (1973).

RESULTS AND DISCUSSION

The male chromosome complement from a spermatogonial metaphase (Fig. 1) shows 2 N = 13 (12 AA + X). The female complement has 2N = 14 (12 AA + XX). All the chromosomes are acrocentric. The six autosomal pairs show a range of size variation between 10.94 and 5.08 expressed in terms of their mean relative length (Table 1). Relative length is calculated as percentage of the total genome length of the cell from which the chromosome is identified. In the idiogram (Fig. 2) the autosomes are numbered 1–6 according to the decreasing order of their lengths. The X-chromosome is negatively heteropycnotic at the spermatogonial metaphase

[1] Department of Biology, Modern College, Poona, India 411005.

TABLE 1. Relative lengths of chromosomes of *Scelimena harpago*.

Chromosome	Relaive length*
1	10.90
2	9.23
3	8.04
4	7.11
5	6.11
6	5.04
X	7.34

* Represents mean of 10 metaphase readings.

and positively heteropycnotic at the prophase (MANNA, 1967). This was also observed in our present investigations. The heterochromatic nature of X–chromosome was also confirmed by the heterochromatin staining method of BOSMAN & SCHABERG (1973). In the family Tetrigidae, the X-chromosome is known to exhibit size variation. Two categories have been established depending upon whether it is small or large (HENDERSON, 1961). In the present case the X-chromosome is of the size of a small autosome and hence of the "Tetrix type".

The above cytological observations on the diploid chromosome number, acrocentric nature of all the chromosomes, XO type of sex determination and the X–chromosome behaviour are comparable wth other species of the family studied so far. All the species, including the one reported here, show necessarily a similar 2N number, the acrocentric nature of the chromosomes and XO type of sex determination (HENDERSON, 1961). These similarities indicate that it is a very close, compact and conservative group, showing karyotypic stabilty, in spite of its world wide distribution.

Acknowledgements:— The authors thank the Director for faclities and Dr. V. G. VAIDYA, Reader in Zoology, M.A.C.S. Research Insititute, Poona, for valuable suggestions in the preparation of the text. One of the authors (SYP) is grateful to Principal M. B. LIMAYE, Modern College, Poona, for his help and encouragement.

REFERENCES

BOSMAN, F. T. & A. SCHABERG (1973) A new G–banding modification for metaphase chromosomes. *Nature (New Biol.)*, **241** : 216–217.

HENDERSON, S. A. (1961) The chromosomes of British Tetrigidae (Orthoptera). *Chromosoma*, **12** : 553–572.

MANNA, G. K. (1967) Cytological analysis of the sex chromosome from testis cells of Grasshoppers—A Review. *Nucleus, Calcutta*, **10** : 64–80.

WHITE, M. J. D. (1951) Cytogenetics of Orthopteroid Insects, 267–330, *in* : *Adv. Genet*, Vol. 4 (ed. DEMEREC, M.) Academic Press, New York.

Fig. 1. Spermatogonial metaphase × 3300.

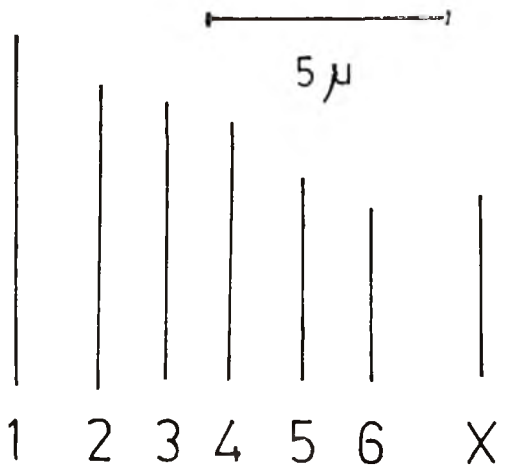


Fig. 2. Haploid metaphase idiogram of male, based on measurements of ten metaphases.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 133 *to* 137

SELECTIVE BREEDING FOR IMPROVING THE FECUNDITY AND SEX-RATIO OF *TRICHOGRAMMA FASCIATUM* (PERKINS) (TRICHOGRAMMATIDAE: HYMENOPTERA), AN EGG PARASITE OF LEPIDOPTEROUS HOSTS[1]

ATMA RAM[2] & A. K. SHARMA[3]
Indian Agricultural Research Institute, New Delhi,
India 110012

(*Received* 10 *February* 1977)

From a culture of the Barbados strain of *Trichogramma fasciatum* (Perkins), subjected to selection for improving fecundity, a strain with improved fecundity could be successfully selected through 16 generations and maintained until the programme was terminated. Sib-mating resulted in reducing considerably the heterogeneity present in the population undergoing selection. A similar selection programme for improving sex-ratio, however, failed to yield significant results.

INTRODUCTION

The potential rate of increase or ability to outnumber host, recognised as a very important attribute of an effective natural enemy, especially in variable environments (SWEETMAN, 1936; DOUTT & DEBACH, 1964) includes in particular a short developmental period and high fecundity. It would be reasonable to assume that natural enemies having these qualities can overtake their hosts quickly. Thus, SZMIDT (1972) reported that the laboratory-selected high-fecundity strains of *Dahlbominus fuliginosus* (NEES) were found to produce higher degree of parasitisation than the wild strain, under field conditions. Keeping this in view, studies were undertaken to improve fecundity and sex-ratio of *Trichogramma fasciatum* (PERKINS).

MATERIALS AND METHODS

A culture of the Barbados strain of *T. fasciatum*, obtained from the Commonwealth Institute of Biological Control, Indian Station, Bangalore for its introduction and establishment in India, being maintained in the Division of Entomology, Indian Agricultural Research Institute, New Delhi, on the eggs of the factitious host *Corcyra cephalonica* (STAINTON), was subjected to selection for improving fecundity and sex-ratio. Mating pairs from the freshly emerged parasite adults, in the general culture were transferred to small shell vials (a pair in each vial) on the inner wall of which streaks of a 1 : 1 (v/v) solution of honey and water had been drawn. After allowing the parasites to feed for about ten minutes, a small egg card bearing about 100 eggs was inserted into each vial. From the second day onwards, a fresh egg card with about 50 eggs was offered every day to each female till it died and the previous day's card was removed. The facundity of each parasite female was recorded separately by counting the number of eggs that turned black. The progeny of the female with highest fecundity was selected in each generation, while that of the other was rejected. The results, in the form of averages of 20 replicates, are presented in Table 1 and graphically represented in the figure.

A similar technique was employed for selecting a strain with impoved sex-ratio. The parents for this study were taken from the strain selected for improved fecundity.

The experiments were conducted at 25 $\pm$ 1°C and 30% relative humidity. Temperature was maintained in an electrically controlled incubator (BOD), while relative humidity was maintained in

[1] A part of Ph. D. Thesis of the senior author.
[2] Assistant Parasitologist, Division of Entomology.
[3] Chief Research Officer-cum-Editor.

desiccators by means of required quantities of potassium hydroxide per 100 ml of distilled water (BUXTON, 1931).

The data collected during the present investigation were subjected to Analysis of Variance. Significant differences or otherwise of the treatments were tested by the C.D. values obtained. Numerical data e.g., those in Table 1 were subjected to square root transformation after adding 0.5 ($\sqrt{x + 0.5}$); while data in percentage (Table 2) angular transformation (consisting in the conversion of numbers into percentage and percentages into angles or degrees) was applied before anlaysing them statistically in order to reduce the variation inherent in the data.

RESULTS AND DISCUSSION

Fecundity

The progeny of the female with the highest fecundity was selected through 16 generations. A significant improvement in the fecundity as a result of selection was achieved in the F_1, average fecundity being 141.10 as compared to 67.95 in parents and there seems to be no further improvement in the fecundity except in F_{16}, which differed with F_1 at 1% level. The improvement in the fecundity achieved by selective breeding in F_1 was maintained in the subsequent generations, till the termination of selection programme (F_{16}) (Table 1; Fig. 1). Similar results have been reported in other *Trichogramma* spp. by DAS (1959), KING (1931) and SHARMA (1968). KING (1931) found that the improvement secured in the F_1 was not maintained in subsequent generations; and this loss of initial improvement may, perhaps be attributed to the inter-racial hybrid nature of F_1, wherein the heterotic effect manifested in high fecundity was lost in subsequent generations. On the other hand, SHARMA (1968) reported that the improvement in the fecundity obtained in F_1 progeny of randomly mated population of five cultures of *T. evanescens minutum* RILEY (According to NAGARKATTI & NAGARAJA, 1968, this species is *T. australicum* GIRAULT) was maintained in subbsequent generation and he considered this situation analogous to the Composites (composite varieties) of maize (*Zea mays*), wherein a number of varieties are combined into a single artificially created population called a Composite. The major advantage of such a complex population is that the yield does not decrease significantly in subsequent generatins. JAIN (1968) ascribed this phenomenon of stabilisation of yields, in advanced generations of composites, to the predominance of additive gene action, unlike the predominance of epistatic and dominance types of gene action in the hybird.

However, URQUIJO (1946) failed to achieve any improvement in the fecundity of *T. minutum* RILEY even after selection through 3,984 generations and reported that average fecundity in most cases was below 40. The possible explantation for this could be: (1) a high degree of homogeneity in respect of genes controlling fecundity in the population undergoing selection, leaving no further scope for improvement, as the success of any breeding programme depends to a large degree upon the amount of genetic variability present in the stock undergoing selection; and/or (2) the predominance of epistatic and dominance type of gene action. SASTRI (1962), in his mainly genetical studies on five races of *T. evanescens minutum*, got some evidence that the fecundity was controlled by two types of interactions: additive at allelic level and epistiatic at non-allelic level.

The population of *T. fasciatum* used in the present investigations showed a high degree of heterogeneity (59.30%) which gave ample genetic scope for selecting a genotype with high fecundity. Sibbing or inbreeding contributed to a considerable amount of homogeneity in the selected population (Table 1; Fig. 1). The increase in

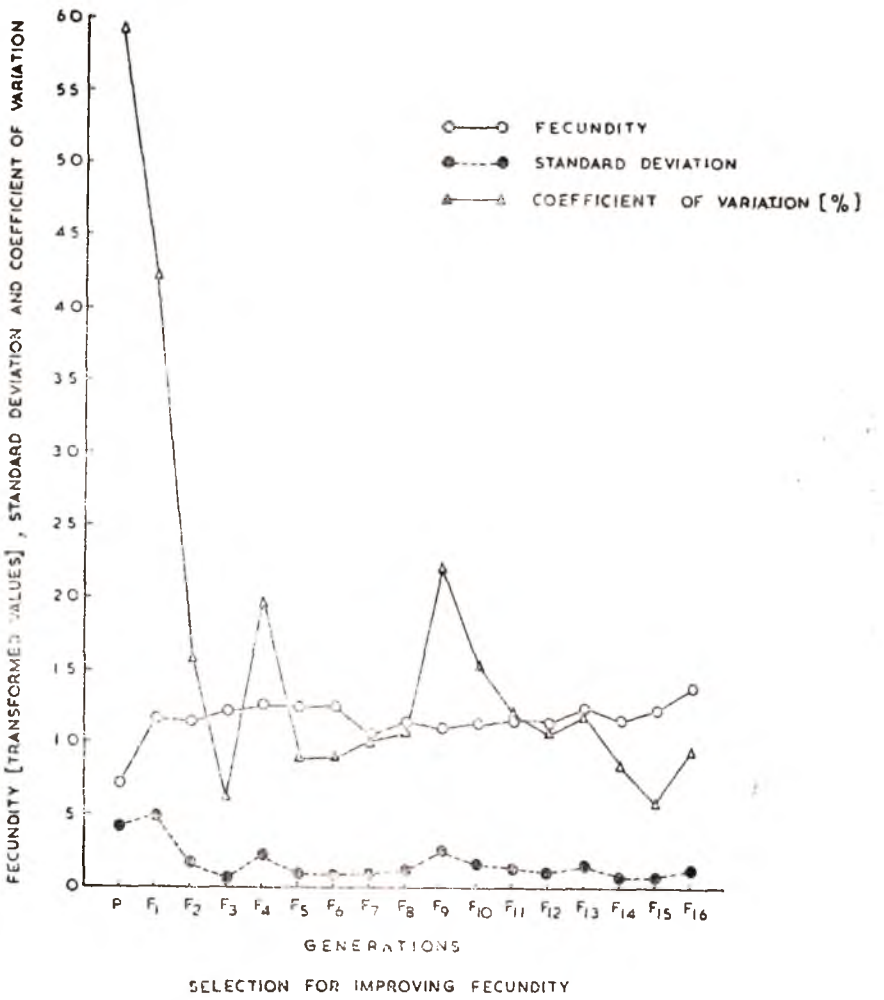


Fig. 1. Graph showing slection of *Trichogramma fasciatum* for improving fecundity.

fecundity by selection may be ascribed to the predominance of the additive gene action in the population thus selected.

Sex-ratio

Selection for improving sex-ratio made through 5 generations did not yield any significant improvement (Table 2). DAS (1959) found a marked increase in sex-ratio in the F_1 of crosses between IARI female × Karnal male of *T. evanescens minutum*. Improvement in sex-ratio of a parasite by selection has also been reported by WILKES (1947) and SIMMONDS (1947). WILKES (1947) reported that by outbreeding and selection for greater number of females in the progeny, it was possible to reduce male sterility from 35 to 2% in *D. fuliginosus*. SIMMONDS (1947) obtained a considerably high degree of improvement in sex-ratio by mating males and females of *Mastrus carpocapsae* (CUSHMAN) from the families

TABLE 1. Selection for improving fecundity.

Generations	Average fecundity		Standard deviation	Coefficient of variation
"P"	67.95	7.24*	4.30	59.30
F_1	141.10	11.68	4.94	42.29
F_2	137.30	11.58	1.84	15.88
F_3	152.45	12.34	0.77	6.23
F_4	140.50	11.65	2.30	19.74
F_5	158.10	12.55	1.14	9.08
F_6	157.40	12.51	1.14	9.11
F_7	110.00	10.45	1.07	10.23
F_8	135.20	11.58	1.26	10.88
F_9	127.25	11.03	2.46	22.30
F_{10}	132.60	11.40	1.76	15.44
F_{11}	136.85	11.63	1.41	12.22
F_{12}	135.10	11.58	1.25	10.79
F_{13}	155.55	12.44	1.49	11.97
F_{14}	139.75	11.80	1.01	8.55
F_{15}	152.75	12.37	0.73	5.91
F_{16}	199.80	14.08	1.38	9.81
S Em ±		0.41		
C D 5%		1.13		
C D 1%		1.49		

* Figures transformed as $\sqrt{x + 0.5}$ (vide Materials and Methods).

TABLE 2. Selection for improving sex-ratio.

Generations	Percentage Female	
	AT values *	RT values *
"P"	53.57	64.33
F_1	52.96	63.36
F_2	54.69	66.37
F_3	53.35	63.99
F_4	53.30	64.19
F_5	54.25	65.59
S Em ± 1.25	NS	

* AT values = averages in degrees; RT values = retransformed values in percengages, obtained in the angular transformation of the data (vide Materials and Methods).

which had high proportion of females and ascribed the improvement to the breeding out of the factor(s) causing male sterility. However, SASTRI (1962) could not obtain an improvement in sex-ratio of *T. evanescens minutum* and concluded that the scope for developing a race with improved sex-ratio is limited because of the fact that the additive gene effects were not pronounced, which may, perhaps, also explain failure to achieve iprovement in sex-ratio during the present investigations.

Acknowledgements:— Thanks are due to the present and former Heads of the Division of Entomology, Dr. N. C. PANT and (the late) Dr. S. PRADHAN for providing all facilities for work and for keen interest in its progress and successful completion.

REFERENCES

BUXTON, P. A. (1931) The measurement and control of atmospheric humidity in relation to entomological problems. *Bull. ent. Res.*, **22** : 431–447.

DAS, L. K. (1959) Studies on the comparative longevity, fecundity and sex-ratio of some races of *Trichogramma evanescens minutum* RILEY. Associateship Thesis, Post-grad. School. Indian Agric. Res. Inst., New Delhi.

DOUTT, R. L. & P. DE BACH (1964) Some biological control concepts and questions, **8**: 118–142 *in*: *Biological Control of Insect Pests and Weeds* (ed P. DE BACH), Reinhold Publishing Corp., New York, 844 pp.

JAIN, H. K. (1968) Development of new crop varieties and some basic genetic studies. *World Science News*, **4** : (I.A.R.I., Special no.), 13–17.

KING, C.B.R. (1931) Report of the Entomologist (for 1930). *Bull. Tea Res. Inst. Ceylon*, No. **5**: 17–20.

NAGARKATTI, S. & H. NAGARAJA (1968) Biosystematic studies on *Trichogramma* species. I. Experimental hybridization between *Trichogramma australicum* GIRAULT *T. evanescens* WESTWOOD and *T. minutum* RILEY. *Tech. Bull. Commonw. Inst. biol. Control*, No. **10** : 81–96.

SASTRY, K. S. SHIVASHANKARA (1962) Studies on the behaviour of some races of *Trichogramma evanescens minutum* RILEY and their crosses. M. Sc. Thesis, Post-grad. School, Indian Agric. Res. Inst., New Delhi.

SHARMA, A. K. (1968) Studies on *Trichogramma evanescens minutum* RILEY (Trichogrammatidae: Hymenoptera) with a view to improving its efficiency as a biological control agent. *Ph. D.* Thesis, Post-grad. School, Indian Agric. Res. Inst., New Delhi.

SIMMONDS, F. J. (1947) Improvement of the sex-ratio of parasite by selection. *Can. Ent.*, **79** : 41–44.

SWEETMAN, H. L. (1936) *The Biological Control of Insects*. Comstock Publ. Co. Inc., Ithaca, N.Y, 461 pp.

SZMIDT, A. (1972) Studies on the efficiency of various strains of the parasite *Dahlbominus fuscipennis* (ZETT.) (Hymenoptera, Chalcidoidea) under natural condition. *Ekol. pol.*, **20**: 299–313.

URQUIJO, P. (1946) Selection des estirpes de *Trichogramma minutum* RILEY de maxima effecti vidad parasitaria. *Boln. Patol. Veg. Ent. agric.*, **14** : 199–216.

WILKES, A. (1947) The effect of selective breeding on the laboratory propagation of insect parasites. *Proc. R. Soc.*, **134** B : 221–245.

Entomon, 1977, *Vol.* 2. *No.* 2, *pp* 139 *to* 140

EFFECT OF FOOD PLANTS ON THE DEVELOPMENT OF *PLUTELLA XYLOSTELLA* (L.) (LEPIDOPTERA, PLUTELLIDAE)

R. B. DUBE & PREM CHAND
Ranchi Agricultural College, Kanke, Ranchi,
Bihar, India

(*Received 4 May* 1977)

Effect of five food plants on the development of *Plutella xylostella* showed that the duration of larval and pupal periods as also per cent individuals reaching adult stage varied with the food upon which the insect was reared. Radish (*Raphanus sativus*) and knolkhol (*Brassica caulorapa*) proved to be unfavourable foods as compared to cauliflower (*B. oleracea* var. *botrytis*), cabbage (*B. oleracea* var. *capitata*) and mustard (*B. compestris*).

INTRODUCTION

Plutella xylostella (L.), the diamondback moth is an oligophagous insect attacking crop plants belonging to the family Cruciferae. In Ranchi (Bihar) its attack has been found to be severe mostly on cauliflower and cabbage.

It has been stated by DETHIER (1954) that criteria customarily accepted in assessing the nutritional value of food are growth, development, longevity and fecundity. In the present investigation an attempt has been made to study the effect of five food plants *viz.*, cauliflower (*Brassica oleracea* var. *botyrtis*), cabbage (*B. oleracea* var. *capitata*), mustard (*B. compestris*), knolkhol (*B. caulorapa*) and radish (*Raphanus sativus*) on the development of larva and pupa of the diamondback moth.

MATERIALS AND METHODS

Studies were carried out at the Ranchi Agricultural College, Kanke, Ranchi, Bihar. Work was initially started with the larvae collected from a nearby village. The larvae were reared in the laboratory on cauliflower leaves. Resulting adults were used in the present investigation.

For the developmental study, moths were allowed to lay eggs on cauliflower seedlings raised in pots. The eggs were isolated and kept in petridishes for hatching. Each petridish had a layer of sand covered with a piece of blotting paper cut to the size of the petridish. This was kept moist throughout till the rearing continued. Caterpillars hatching on the same day were transferred in batches of ten on different foods placed in separate petridishes. Food was replenished every alternate day or whenever felt necessary. Observations on the larval and pupal periods as also per cent reaching adult stage were recorded.

RESULTS AND DISCUSSION

Results of the experiment have been summarised in the Table below.

Mean number of days required for completion of the larval stage varied from 7.9 on cauliflower to 11.0 on knolkhol. Larval period on cauliflower was significantly shorter than on all the other food plants except radish (8.3 days).

Food plants did not appear to have marked effect on the pupal development. It was only knolkhol (6.8 days) which showed significantly greater duration of pupal stage. On the other food plants the range was 5.4 to 6.1 days.

When the total larval and pupal period was considered, the mean durations ranged

TABLE 1. Duration of larval and pupal stages of *P. xylostella* on different food plants.

Food plant	Duration of larval and pupal stages (in days)						Per cent individuals reaching adult stage
	Larva		Pupa		Total larval and pupal stage		
	Range	Average	Range	Average	Range	Average	
Cauliflower	7–9	7.9	4–7	5.4	11–16	13.3	67.5
Cabbage	8–10	9.1	5–6	5.7	13–16	14.8	47.5
Mustard	8–10	8.3	5–7	5.9	13–17	14.2	60.0
Knolkhol	10–12	11.0	6–8	6.8	16–20	17.8	41.7
Radish	9–11	9.5	5–7	6.1	14–18	15.6	35.0

between 13.3 and 17.8 days. Total period occupied was highest on knolkhol which appeared to be an inferior food for the diamondback moth. Although, there was not much difference between cauliflower (13.3 days), cabbage (14.8 days) and mustard (14.2 days) the periods on radish and knolkhol were 2.4 and 4.5 days more than that on cauliflower.

Food plants were found to have marked influence on the per cent individuals reaching adult stage. 67.5 percent on the caterpillars could develop into adult on cauliflower which was closely followed by cabbage (60.0 percent). Lowest percentage of individuals reached adult stage on radish (35.0 percent). It was interesting to note that although knolkhol appeared to be an unfavourable food with regard to development of the insect, it supported life greater (41.7 per cent) than mustard.

It has been reported (GUNN, 1917; PERRY, 1974; VERMA & SANDHU, 1976) that the diamondback moth damages various cruciferous crop plants seriously. Tne present investigation suggests that although the insect attacks a variety of crop plants it shows marked preference for some of them *viz.*, cabbage, cauliflower and mustard. Adverse effect of the other two food plants on development may possibly be because of their physical and chemical properties. Radish leaves are hairy and coarse while those of knolkhol are waxy and light green as against succulent and nonhairy nature of other hosts. Although knolkhol appears to be an inferior food it contains more protein than radish (Choudhary, 1970). When this plant is compared with the others it contains more of fibre and sodium and less of calcium which might have also played a role in making it an unfavourable food.

Acknowledgement:- The authors are grateful to Prof. S. M. ALAM, Principal, Ranchi Agricultural College for extending necessary facilities for the work.

REFERENCES

CHOUDHARY, B. (1970) *India, the Land and the People : Vegetables.* National Book Trust, India, 61–191.

DETHIER, V. G. (1954) Evolution of feeding preference in phytophagous insects. *Evolution*, **8** : 73.

GUNN, D. (1917) The small cabbage moth. *Union S. Africa Dept. Agric. Pretoria. Bull.*, **8** : 10.

PERRY, W. M. (1924) *Insect Control Report*, 13, Virginia Island Agril. Expt. Sta.

VERMA, A. N. & G. S. SANDHU (1967) Relative effiiciency of different insecticides as contact poison to the larvae of diamondback moth. *J. Res. Punjab. Agric. Univ.* **4** (4): 555–559.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 141 *to* 144

BIONOMICS OF THE RICE CUTWORM, *MYTHIMNA SEPARATA* (WALKER)

DWIJENDRA SINGH & LALLAN RAI
Department of Entomology, Banaras Hindu University, Varanasi, India 221005

(*Received* 27 *April* 1977)

The biology of the rice cut worm, *Mythimna separata* (WALK.) has been studied under laboratory and field conditions at Varanasi (U. P.) during September—November, 1976. The average incubation period, total larval period and pupal period are 2.0, 14.6, 8.6 days within laboratory and 2.4, 21.4, 9.18 days under field conditions. Total duration from egg to adult of female and male is 41.8 and 38.8 days in the laboratory and 48.2 and 45.4 days in field conditions respectively. The nature of damage is also reported.

INTRODUCTION

The rice ear-cutting caterpillar (the rice cutworm), *Mythimna* (*Pseudaletia*) *separata* (WALK.) was previously considered as a minor and sporadic pest of rice (FLETCHER, 1917). With the introduction of dwarf and high yielding varieties and the associated changes in agro-ecosystem, the status of this pest has changed from minor to a major pest of rice. Severe damage is caused by larva of the pest when the crop is approaching maturity (KULSHRESHTHA *et al.*, 1970). Since 1971, the infestation has been encountered on paddy at Varanasi region (KATIYAR *et al.*, 1972). Very little work has been done on the biology and habits of *M. separata* in India (AVASTHY & CHOUDHARY, 1965; KULSHRESHTHA *et al.*, 1970; BINDRA & SINGH, 1973). Keeping this in view, an attempt has been made to study the bionomics of this notorious pest at Varanasi.

MATERIALS AND METHODS

Laboratory studies

Full grown larvae of *Mythimna separata* were collected from the paddy fileds and reared in the laboratory to obtain adults. The adults thus obtained were kept in pairs in glass chemneys (20 × 8 cm) covered with muslin, for observation. Ten such pairs of moths were employed for this study. They were provided with piece of folded black paper for oviposition.

Field studies

In this case potted paddy plants were used. Each pot had sigle hill and was caged with (90 × 30 cm) wire net. One male and one female moth were released in each cage and ten such sets were studied. A piece of cotton swab soaked in 10% honey was provided as food for adult moths for field and laboratory studies.

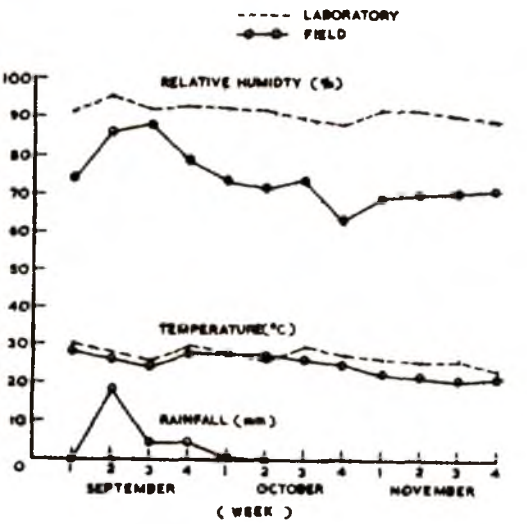


Fig. 1. Meteorological data (weekly mean) during biological studies of *M. separata* (WALK.).

Immature stages were studied by rearing freshly hatched individual larvae on tender leaves. The moulting was confirmed by exuvial head capsule. The entire studies were carried out during September–November 1976 and the meteorological data are presented in Fig. 1.

RESULTS AND DISCUSSION

Nature of damage

Damage to the paddy leaves and ears is caused only by the caterpillars. The newly hatched larvae feed on the epidermis of tender leaves. Second and third instar larvae feed by cutting the leaf from edge towards midrib. The 4th, 5th and 6th instar larvae also cut the panicles of rice during night.

Life-history

The data on fecundity and incubation period of egg are presented in Table 1. Mean pre-oviposition period was 4.4 days in the laboratory and 5.0 days in the field. Mating was a prerequisite for laying the fertile eggs. Before copulation the male moths were active and excited, while the female moths were passive. The moths mated end to end and mating took place only during night. One to two days after mating, the female laid eggs, usually in overlapping rows and occasionally singly or in clusters in a narrow place i.e., leaf sheath in the field. In the laboratory, eggs were also laid on paper and glass surface. The oviposition period ranged from 3.0 to 7.0 under both laboratory and field conditions. Data on fecundity of the animal and incubation period of eggs are given in the Table. The eggs were round and spherical and uniformly light brown which changed to pale-yellow as they grew older, and finally blackish before hatching. The average diameter of freshly laid egg awas 0.6 mm.

TABLE 1. Duration of various life stages of rice ear-cutting caterpillar, *Mythimna separata* (WALK.) on rice.

Particulars	Mean* duration (days)	
	Laboratory	Field
Incubation period	2.0	2.4
Larva		
First instar	2.6	3.4
Second instar	2.6	4.0
Third instar	3.4	4.4
Fourth instar	2.6	4.0
Fifth instar	3.2	3.2
Sixth instar	2.2	2.4
Total larval duration	14.6	21.4
Prepupa	1.8	2.0
Pupa	8.6	9.8
Total duration from egg to adult :		
Female	41.8	48.2
Male	38.8	45.4
Longevity of adult moth :		
Female	12.8	12.6
Male	9.8	9.8

* Mean of ten replications.

The data on larval instars are contained in the Table. The larva moulted six times. The newly hatched larva was dark gray with brown head capsule. Hairs were sparsely scattered over the body. It measured 1.8 ± 0.1 mm in length. The second instar was 9.5 mm, having green body and light-brown head. There were light brown longitudinal, parellel stripes on the dorsolateral side of the body. The third instar was light brown in colour having two parellel yellowish-brown stripes on each side and one dorsal median white thread like lining. The head capsule was reddish-brown. It was 20.4 mm long. The fourth instar larva had comb-like black linings on head capsule. The prothoracic shield was well developed. The larva maeasured 25.0

mm. There were clear and prominent stripes on the fifth instar also. The head capsule was shining reddish brown. The larva measured 30.5 mm now. The full grown sixth instar larva measured 38.7 mm. It stopped feeding for last two days, remained motionless and gradully reduced in size and changed into a reddish brown pupa after moulting. Pupation in the laboratory took place under blotting paper kept in petridishes without making any cocoon, but in the field it pupated in clumps of paddy, cracks and crevices and in loose soil by making earthen cocoon. The colour of pupa was reddish brown and became blackish before emergance of adult. The pupa measured 16.5 $\pm$ 2.0 mm in length and 4.0 $\pm$ 0.5 mm in width.

The adult is a medium size, pale-brown moth. The female measured 40.0 mm and male moth 35.0 mm in length with both forewings expanded. The male possesses a pair of yellow brushlike structures on the ventral side of thorax whereas they were absent in the female. The forewings were pale-brown and hind wings were translucent gray in colour.

Seasonal history

Seasonal occurrence of this pest on rice in the farm was studied. Two generations under the field conditions were recorded during July to December under the agro climatic conditions of eastern Uttar Pradesh causing damage to rice crop.

Apanteles spp. and *Xanthopimpla emaculata* SZIP were recorded as parasites on this pest.

In the agro-climatic conditins of eastern Ontario (Canada) fecundity of *M. separata* was found to be 967 eggs per female under laboratory conditions (GUPPY, 1961) while POND (1960) observed that the females were found capable of laying more than 1,400 eggs. He however, did not mention the temperature and relative humidity. In the present studies it was observed to be on average 745.4 and 820.4 eggs per female under laboratory and field experiments respectively.

The incubation period of 5 to 13 days has been recorded on rice in Bangladesh (ALAM, 1960). However, in the present studies the incubation period varied from 2 and 3 days under laboratoy and field conditions, respectively. ALAM (1960) further reported that the total larval duration was 20 to 48 days while PUTTARUDIRAH & USMAN (1957) recorded it to be 22.5 days. In present investigation the larval period was found to be 14.6 days in the laboratory and 21.4 days in the field experiment.

The pupal period averaged 8.6 days under laboratory and 9.80 days under field conditions which also supports the findings of AVASTHY & CHOUDHARY (1965) being 8 to 9 days on sugarcane host. They further noted that the life span of adult ranged 4 to 5 days in summer and 6 to 7 days in winter under laboratory conditions while in this study the longevity of male and female was recorded to be on an average 9.6 and 12.8 days under laboratory and 9.8 and 12.6 days in the field conditions on 10% honey solution during rainy season. KULSHRESHTHA *et al.* (1970) have reported that the males lived for 4 to 9 days while females for 6 to 11 days which also supports the findngs of the present studies.

Acknowledgement:– The authors are grateful to Shri BALRAM SINGH, Dy. Director cum Incharge, Regional Demonstration and Agricultural Testing Centre,, Lahartara, Varanasi, for providing necessary facilities at State Gvernment's Agricultural Farm, Lahartara, Varnasi (U. P.).

REFERENCES

ALAM, M. Z. (1960) On the biology of rice ear-cutting caterpillar, *Pseudaletia unipuncta* (HAWORTH) in East Pakistan. *Agriculture Pakist.*, **11** : 560–572.

AVASTHY, P. N. & J. P. CHOUDHARY (1965) Biology and control of army-worm, *Pseudaletia unipuncta* HAW. *Indian Sug. J.*, **9**: 249–251.

BINDRA, O. S. & J. SINGH (1973) Bionomics of the armyworm, *Mythimna separata* WALKER (Lepidoptera : Noctuidae) at Ludhiana, Punjab. *Indian J. agric. Sci.*, **43** : 299–303.

FLETCHER, T. B. (1917) Sugarcane, paddy and other cereals, grasses and fodder crops. *Rep. Proc. 5th ent. Meet. Pusa*, 137–209.

GUPPY, J. C. (1961) Life-history and behaviour of the armyworm, *Pseudaletia unipuncta* (HAW.) (Lepidoptea : Noctuidae) in eastern Ontario. *Can. Ent.*, **93** : 1141–1153.

KATIYAR, O. P., LAKSHMAN LAL, A. R. REDDY & S. P. MUKHARJI (1972) Out-break of rice armyworms at Varanasi. *Curr. Sci.*, **41** : 579.

KULSHRESHTHA, J. P., M. B. KALODE & A. VARMA (1970) Paddy cutworm (*Pseudaletia separata* WALKER) and armyworm (*Cirphis compta* MOORE) as serious pests of high yielding varieties of rice. *Oryza*, **7** : 143–145.

POND, D. D. (1960) Life-history studies of the armyworm, *Pseudaletia unipuncta* HAWORTH (Lepidoptera : Noctuidae) in new Brunswitch, *Ann. ent. Soc. Am.*, **53** : 661–665.

PUTTARUDIRAH, M. & S. USMAN (1957) Flood causes armyworm outbreak. *Mysore agric. J.*, **32** : 124–131.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 145 *to* 147

BIOLOGY OF *ACANTHOCORIS SCABRATOR* FABR., A PEST OF MANGO

GEORGE KOSHY, A. VISALAKSHY & M. R. G. K. NAIR
Division of Entomology, College of Agriculture, Vellayani, India 695522

(*Received 3 September 1977*)

Biology of *Acanthocoris scabrator* FABR. (Coreidae: Heimptera) a pest of mango in Kerala was studied under laboratory conditions. It breeds on *Ipomea carnea*. Female lays 50 to 60 eggs after 7 to 9 days of emergence. The incubation period is 7 to 8 days. There are five nymphal instars, the total period of nymphal development being 50 days. Adults live for 3 to 4 months. The adult bugs damage unripe mango fruits by sucking the juice, the attacked fruits eventually rot and drop.

INTRODUCTION

Acanthocoris scabrator FABR. (Coreidae : Hemiptera) was observed as a pest of mango at Trivandrum, Kerala State. The occurrence of this insect in India ws reported by LEFROY (1909). HOFFMANN (1928) reported it as a pest of Cape gooseberry (*Physalis peruviana*), two varieties of red pepper (*Capsicum*) and of egg plant (*Solanum melongena*) and squash (*Cucurbita maxima*) in Canton. MILLER (1931) reported it as a pest of solanaceous and convolvulaceous crops in Malaya. Since it is a new pest of mango and as no information is available on its biology in this country studies were made on it, the results of which are presented in this paper.

MATERIALS AND METHODS

The bugs were collected from *Ipomea carnea* in a mango orchard in Trivandrum during August September, 1976. The adults were kept for egg laying in cylindricl glass jars (25cm × 15 cm) covered with muslin cloth and containing branches of *Ipomea* plants. The first instar nymphs were confined singly on tender leaves of the host plant inside glass chimneys.

OBSERVATIONS AND DISCUSSION

Mating and Oviposition

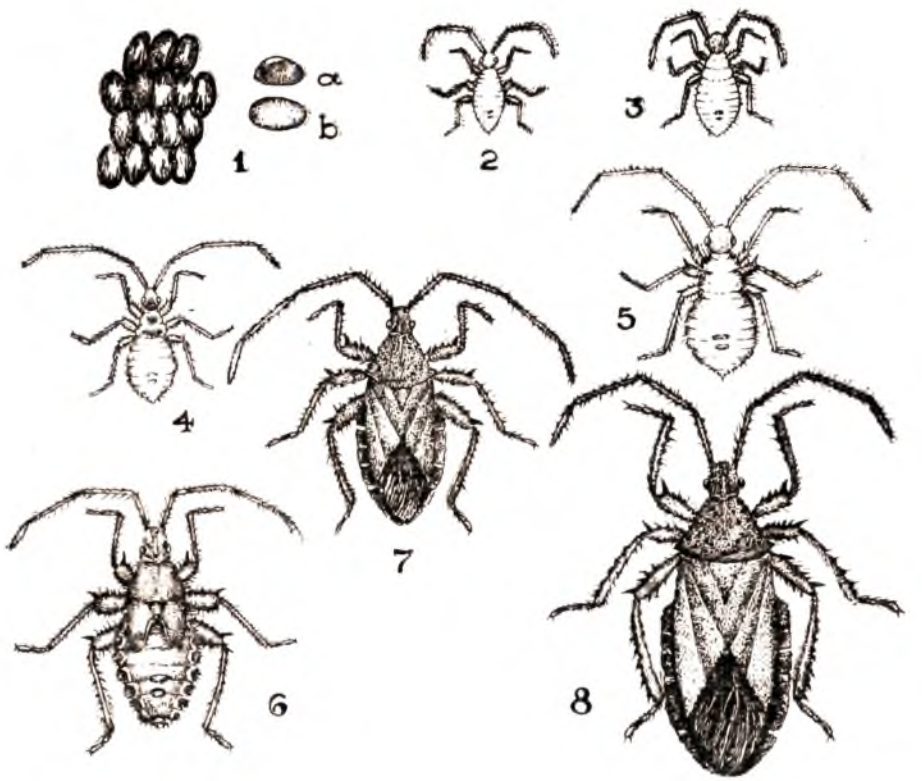
Mating commences two to four days after adult emergence and takes place during night. Egg laying starts 7 to 9 days after emergence. Eggs are laid singly in batches of 18 to 20 on the undersurface of the leaves. A female bug lays 50 to 60 eggs.

The Egg (Figs. 1 a & b)

It is ovoid in shape with a flat bottom and shining brown in colour. It measures 2.43 mm length and 1.62 mm in width. The egg period ranges from 7–8 days in September–October. The first instar nymph emerges by cutting the egg shell at one end of the egg.

The Nymph (Figs. 2 to 6)

There are five nymphal instars. The important morphometric features are given in Table 1. On hatching the nymphs are red in colour and slowly change to black. They congregate on the under surface of the leaves for some time after hatching and then distribute themselves to the tender



Figs. 1 to 8. Life stages of *Acanthocoris scabrator* Fabr.
1. Egg (a) Side view; (b) Dorsal view; 2. 1st instar nymph; 3. 2nd instar nymph; 4. 3rd instar nymph; 5. 4th instar nymph; 6. 5th instar nymph; 7. Adult male; 8. Adult female.

leaves and start feeding. The head is triangular with a long rostrum. The antenna is 4-segmented the 2nd segment being the longest. The prothorax is smaller than the meso- and metathorax. The edges of the thoracic segments have minute spines on them. Wing buds first appear in the fifth instar. Abdomen is flat and light greenish in colour. On the 4th and 5th abdominal segments semicircular brownish flaps are seen mid-dorsally. The 3rd and 4th instar nymphs are greenish white in colour; the final instar has the same shape and colouration as the adult.

Adult

The adults (Figs. 7 & 8) are brown in colour. The wings, when at rest do not cover the abdomen fully; the abdomen projects laterally beyond the hemelytra. Females are distinguishable by their bulging abdomen. The adults live for 3 to 4 months. They are not swift fliers but are swift runners. They remain congregated on stem.

Damage caused

The adult bug damages unripe mango fruit by feeding on it. It thrusts its mouthparts into the fruit and sucks the juice. Many feeding punctures are seen on fruits through which the juice exudes. Secondary infection by microbes causes formation of black rings around the feeding punctures which later spread and lead to total rotting

TABLE 1. Important features of nymphs and adult of *A. scabrator* (data is the mean of ten measurements).

	Instars					
	I	II	III	IV	V	Adult
Body length (mm)	3.79	4.4	5	6.5	9.0	14.0
Width of thorax (mm)	1.2	1.35	1.5	2.0	3.5	5.0
Head width (mm)	1.08	1.2	1.35	1.62	1.89	3.24
Length of antenna (mm)	4.37	6.21	9.23	12.69	14.96	17.55
Duration (in days)	4.0	6.0	6.0	10.0	20.0	

of the fruit. In an orchard varieties Malgoa and Himampasanth alone were seen attacked while the local varieties were not attacked.

On the host plant *Ipomea carnea* the 1st instar nymphs feed on the underside of the tender leaves clustering in large numbers. Later instars feed on the vines. The feeding punctures are visible as reddish brown spots. When the infestation is severe the vines wilt. The adults also feed on the *Ipomea* vines.

REFERENCES

HOFFMANN, W. E. (1928) Notes on a squashbug of economic importance. *Lingnan Sci. J.*, **3** : 281–292.

LEFROY, H. M. (1909) *Indian Insect Life*. Agricultural Research Institute, Pusa, 683 pp.

MILLER, N. C. E. (1931) The bionomics of some Malayan Rhyncota (Hemiptera-Heteroptera). *Scient. Ser. Dep. Agric. Straits Settl. F. M. S.* **5** : 142.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 149 *to* 151

INFLUENCE OF IRRIGATION ON THE NESTING ACTIVITY OF *ANDRENA ILERDA* CAM. (ANDRENIDAE: HYMENOPTERA) IN WHEAT FIELDS NEAR *BRASSICA CAMPESTRIS* VAR. *TORIA*

G. S. GREWAL
Department of Entomology, Punjab Agricultural University, Ludhiana, India 141004

(*Received 7 May 1977*)

The activity of soil nesting bee, *Andrena ilerda* was hampered by irrigation of the nesting areas close to a *Brassica campestris* field in bloom. The percentage of nests where activity was revived within 16 days was 7.79 when the field was irrigated during the day and 2.88 when irrigated at night. When half of the nesting area was irrigated in the day, the number of active nests in the non-igrrigated half increased significantly. Irrigation at night trapped the bees in their nests and resulted in a steep decline in the number of females foraging on *Brassica campestris*.

INTRODUCTION

Andrena ilerda CAM. is an important pollinator of *Brassica campestris* vars. *toria* and *sarson* (ALI, 1935; RAHMAN, 1940). Of the solitary bees associated with *Brassica*, *Andrena ilerda* is widely distributed and is most abundant on these crops in the Punjab (KAPIL *et al.*, 1971). The females of this species make their nests in the soil, often in the newly sown wheat fields, near flowering *Brassica* crops. They are active from November to March. Depending upon the sowing time, first irrigation to wheat fields is applied towards the end of November or in December which is likely to hamper nesting activity of the bees. Field is irrigated either during the day when most of the females are actively foraging, or at night when they are in their nests. It was therefore desired to study the influence of irrigation on the nesting and field activity of these bees under the two conditions.

MATERIALS AND METHODS

A late sown *toria* crop., 0.4 ha in bloom and two adjoining newly sown wheat fields, 0.4 ha each with large aggregations of *Andrena ilerda* nests were selected for this study. Other fields near *toria* were having either sugarcane or *berseem* growing in them and were thus unsuitable for the bees to make nests. In the two wheat fields, nests within 30 m distance of the outer margin of *toria* crop were counted before irrigation. Each nest was marked by fixing a piece of reed near it. Half of the nesting area (Field A) was irrigated during day time between 11.00 hr and 16.00 hr. The second half of the nesting area (field B) was irrigated at night. The total number of nests revived within 16 days of irrigation was counted. After irrigation of field 'A' the increase in the nesting activity of bees in non-irrigated field 'B' was observed by counting the nests at weekly intervals in four sample plots, 10 m $\times$ 10 m each marked at random within 30 m of the outer margin of *toria* crop. Fluctuation in the number of bees foraging on *toria* flowers was studied by counting the females caught in 50 net sweeps, before irrigation of the nesting area, after irrigation of half of the nesting area in the day time, and after irrgation of the half at night. These observations were repeated on four days. A handnet 38 cm diameter and with a conical bag was used for this purpose. The net was moved through 180° angle for making sweeps over the crop between 12.00 and 14.00 hr which is the period of maximum activity of *Andrena ilerda* (SIDHU, 1968). The bees caught were counted and released.

RESULTS AND DISCUSSION

The data on active nests marked in the two fields before irrigation and the nests

revived within 16 days of irrigation are presented in Table 1. It was observed that irrigation of the nesting area hampered the nesting activity of *Andrena ilerda* irrespective of the time of irrigation. The percentage of the nests where activity was revived was very low in both the cases, being 7.79 when irrigation was in the day and 2.88 when it was at night. In both the cases, all the nests where activity was revived were on raised 'bandhs'.

TABLE 1. Revival of the nests of *A. ilerda* after irrigation.

Particulars	Field 'A' irrigated in day time	Field 'B' irrigated at night
Number of nests before irrigation	154	139
Number of nests revived within 16 days of irrigation	12	4
Percentage of the nests revived	7.79	2.88

After irrigation of half of the nesting area (field A) during the day, the number of active nests in the nonirrigated half increased significantly. Weekly observations in the nonirrigated portion are presented in Table 2. It was observed that most of the new nesting tunnels were dug within one week. A control plot kept under observation at a distance of 5 km showed no increase in the number of nests during the same period. *Andrena ilerda* completes two generations in a year. Since the females of the new brood of *Andrena ilerda* emerge towards the end of December this increase in the number of nests cannot be attributed to the emergence of new females. Moreover this *toria* field, being a late sown crop in the area, was completely isolated. There was no other field in bloom within 1000 m of the crop. It left little chance for the *Andrena ilerda* females to come from the adjoining fields. Evidently some females which had their nests in field 'A' shifted nesting activity to the nonirrigated portion of nesting area. Biological studies made earlier also indicate that *Andrena ilerda* females make more than one nest in their life time (SIDHU, 1968).

TABLE 2. Counts of the nests of *A. ilerda* CAM. (mean of four plots) in nonirrigated field 'B' before and after irrigation of field 'A'.

Date	Active nests per 100 m²	
13-11-1975	51.00	
20-11-1975	52.25	
Field 'A' irrigated on 21-11-1975		CD (p=0.05) = 7.73 CD (p=0.01) = 9.59
27-11-1975	64.25	
4-12-1975	68.50	

Wheat field 'B' was irrigated on 6th December at night when the soil-moisture in field 'A' was suitable for digging nesting tunnels and it was already having 6.25 nests per 100 m². But this did not significantly increase the nesting activity in field 'A'.

TABLE 3. Number of *A. ilerda* females caught in 50 net sweeps from *Brassica campestris* field (mean of four observations).

Occasion	Bees/50 net sweeps	
Before irrigation	8.25	
After irrigation of half of the nesting area during the day	7.50	CD (p=0.05)=1.61 CD (p=0.01)=2.66
After irrigation of half of the nesting area at night	3.75	

The fluctuation in the number of females foraging in the *Brassica* field were studied by taking the counts of *Andrena ilerda* females caught in the samples (Table 3). It was observed that when half of the nesting area was irrigated during the day there was only an insignificant reduction in the number of bees. But when half the field was irrigated at night, it resulted in a significant reduction in the number. This was indicative of the fact that irrigation at night trapped the females in their nests and reduced the number of pollinators on *Brassica*.

It could thus be concluded that irrigation could best be applied during the day and it was desirable to irrigate nesting areas in parts.

Acknowledgements:– The author is thankful to Dr. A. S. SIDHU, Professor and Head, Department of Entomology, Punjab Agricultural University, Ludhiana for the facilities provided and for going through the manuscript critically.

REFERENCES

ALI MOHD (1935) Pollination studies in *toria* and *sarson*. *Indian J. agric. Sci.*, **5** : 125–154.

RAHMAN, K. A. (1940) Insect pollinators of *toria* and *sarson* at Lyallpur. *Indian J. agric. Sc.*, **10** : 422–447.

KAPIL, R. P., G. S. GREWAL, S. KUMAR & A. S. ATWAL (1971) Insect pollinators of rape-seed and mustard. *Indian J. Ent.*, **33** : 61–66.

SIDHU, A. S. (1968) Studies on the field activity and nesting behaviour of some andrenid bees in the Punjab. Ph. D. Thesis, Punjab Agricultural University, Ludhiana (Unpublished), 127 pp.

Entomon, 1977, *Vol.* **2**, *No.* 2, *pp.* 153 *to* 155

FIELD EVALUATION OF SOME SORGHUM SELECTIONS FOR RESISTANCE TO SHOOTFLY AND STEM BORER

G. G. KUNDU, PREM KISHORE & M. G. JOTWANI
Division of Entomology, Indian Agricultural Research Institute,
New Delhi, India 110012

(*Received 15 June 1977*)

Field studies were conducted to screen four hundred and fifty derivatives, obtained from crosses between high yielding and resistant varieties, for shoot fly and stem borer damage. Twenty lines, having either M-35-1 or BP-53 as one of the resistant parents, were selected as highly promising for exhibiting desirable level of resistance to both the shootfly and stem borer.

INTRODUCTION

Sorghum (*Sorghum bicolor*), an important cereal crop of our country, occupying an area of about 18 million hectares, is infested by two major insect pests *viz.*, shoot fly *Atherigona soccata* (RONDANI) and stem borer *Chilo partellus* (SWINHOE). Both the insects are internal feeders and cause severe damage to the crop.

Effective chemical control for these two tissue borers has been evolved but because of various limitations, especially the economic condition of an average sorghum cultivator, there is need to develop sorghum varieties resistant to these insect species. The first pre-requisite for breeding a crop variety resistant to a particular insect is to identify resistant genes for that insect by screening the available germ-plasm collected from different parts of the globe (PAINTER, 1951).

Highly promising sources of resistance in sorghum to the two pests were identified by earlier workers (SINGH *et al.*, 1968; PRADHAN 1971). Th sorghum breeders had crossed two of these selected lines *viz.*, M–35–1 and BP–53 with some agronomicaily desirable lines and made selections of lines showing desirable agronomic characters in F_2. In F_3 generations selections were made for both the desirable agronomic characters as well as for resistance to shoot fly and stem borer at Delhi. These selected lines in advanced segregating generations were screened for resistance to shoot fly and stem borer at Udaipur (Rajasthan). The results of this screening are presented in this paper.

MATERIALS AND METHODS

Four hundred and fifty promising selections were sown on the 8th and 9th July, 1968 to screen them for resistance to shoot fly and stem borer under natural infestation conditions. The trial was conducted at the University Research Farm Vallabhnagar (Udaipur). Each line was grown in a single row 3 m long. Row to row distance was maintained at 75 cm and plant to plant distance at 15 cm. Four days after germination excess seedlings were thinned and only one seedling was kept per hill. On the 14th and 21st day after germination, dead hearts due to shoot fly and total number of plants in each row were counted. After taking observations for shootfly infestation, the infested seedlings were pulled out and the remaining plants were kept for taking observations on stem borer damage. Counts on dead hearts due to stem borer and total number of plants were recorded on 30th and 60th day after germination. Similarly, the entries were visually graded for borer leaf injury

TABLE 1. Relative susceptibility of sorghum selections to infestation by shoot fly and stem borer (F_4).

Selections	Pedigree	Per cent dead heart due to		Per cent stem tunnelling by stem borer	Visual grading for damage due to stem borer
		Shoot fly	Stem Borer		
DK '67 IR. 6–1	IS 84 X BP–53	0.00	6.66	18.31	1
DK '67 858–1	IS 531 X M 35–1	0.00	0.00	12.56	1
DK '67 857–2	IS 531 X M 35–1	2.05	0.00	17.34	1
DK '67 858–2	IS 531 X M 35–1	0.00	0.00	22.83	1
DK '67 544–1	IS 369 X BP 53	0.00	6.25	12.71	1
DK '67 652–5	CK 60 X BP 53	0.00	7.14	22.40	1
DK '67 499–1	IS 369 X BP 53	8.33	0.00	10.75	1
DK '67 IR 182–1	IS 369 X BP 53	0.00	0.00	21.40	1
DK '67 887–1	IS 76 X BP 53	0.00	0.00	20.65	1
DK '67 634–2	CK 60 B X BP 53	0.00	5.80	16.52	1
DK '67 IR 326–2	CK 60B X BP 53	0.00	5.89	19.75	0
DK '67 664–1	CK 60B X BP 53	0.00	0.00	24.91	1
DK '67 633–1	CK 60B X BP 53	0.00	0.00	6.82	1
DK '67 641–1	CK 60B X BP 53	0.00	0.00	21.77	1
DK '67 595–1	CK 60B X BP 53	0.00	1.88	20.92	1
DK '67 595–2	CK 60B X BP 53	0.00	0.00	23.73	1
DK '67 469–1	IS 369 X BP 53	0.00	0.00	15.64	1
DK '67 591–1	CK 60B X BP 53	0.00	0.00	15.71	1
DK '67 411–1	IS 2954 X BP 53	0.00	0.00	16.25	1
DK '67 766–1	IS 2950 X M 35–1	0.00	0.00	15.90	1
CSH–1 (Check)		12.25	45.95	38.24	8

on 40th and 60th day after germination, the scale used was 0 (no damage) to 9 (severe damage). At harvest, 25 per cent randomly selected plants in each row were taken for recording extent of stem tunnelling by the borer. All data were converted into percentages.

RESULTS AND DISCUSSION

The observations recorded (Table 1) on shoot fly infestation reveals that the percentage dead hearts varied from 0.00 to 64.00. Out of 450 lines studied, 60 lines had 10% or less dead hearts.

The dead hearts percentage due to stem borer ranged from 0.00 to 33.33 in F_3 lines and 0.00 to 86.6 in F_4 lines. The visual grading for leaf injury indicated that certain lines were highly susceptible and showed severe chewing and perforation of leaves made by the young larvae feeding inside leaf whorls. Such lines were placed in grade 9. Stem tunnelling showed wide variations in different lines and ranged from 6.82 per cent to 100.00 per cent. On the basis of damage data, 20 lines were selected as highly promising. These lines listed in Table 1, show desirable level of resistance to both the shoot fly and stem borer. The dead hearts due to shoot fly in the selected lines ranged between 0.00 to 8.33 per cent and due to stem borer between 0.00 to 7.14. There was hardly any borer leaf injury in these lines, the visual grading at growth stage was either 0 or 1. The percentage stem tunnelling in these lines ranged between 6.82 to 24.91. It appears the tunnelling in most of the lines must have been caused at the late stage of the growth, since in spite of the fairly high percentage of tunnelling the plant stand in the selected lines was found to be very good at the time of harvest.

These studies have indicated that the resistant genes contributed by M–35–1 and BP–53 have been responsible for maintaining fairly high degree of resistance to the two pests in advance generation selections. Some of these selections have proved to be good yielders and a few of them *v.z.*, 447 (IS 2954 x BP 53) and E 302 (CK 60 B x BP–53) would be introduced into yield trials.

Acknowledgement:– The authors are thankful to the late Dr. B. K. SRIVASTAVA, Director (Research), Agricultural Experiment Station, University of Udaipur, for providing necessary facilities to carry out these investigations. Thanks are also due to Dr. N. G. P. RAO, Project Co-ordinator (Sorghum) for supplying the research materials. This research has been financed in part by the PL–480 Project No. A7–ENT–120.

REFERENCES

PAINTER, R. H. (1951) *Insect Resistance in Crop Plants*. Macmillion Co., New York, 520 pp.

PRADHAN, S. (1971) *Investigations on Insect Pests of Sorghum and Millets* (1965–1970). Final Technical Report. Division of Entomology, Indian Agricultural Research Institute, New-Delhi, 123–130 pp.

SINGH, S. R., G. VEDA MOORTHY, V. V. THOBBI, M. G. JOTWANI, W. R. YOUNG, J. S. BALAN, K. P. SRIVASTAVA, G. S. SANDHU & N. KRISHNANANDA (1968) Resistance to the stem borer *Chilo zonellus* (SWINHOE) and stem fly *Atherigona varia soccata* ROND. in the World Sorghum Collection in India. *Mem. ent. Soc. India*, 7 : 2.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp* 157 *to* 159

RESIDUES OF ENDOSULFAN, CARBARYL AND MALATHION IN MAIZE

V. S. KAVADIA, H. C. L. GUPTA, B. L. PAREEK & K. P. SHARMA
Department of Entomology, College of Agriculture, University of Udaipur, Udaipur, India 313001

(*Received 4 May 1977*)

The application of 0.04% endosulfan EC, 0.2% carbaryl (sevimol 40LV) and 0.05% malathion EC at the rate of 1000 l per h.a. on maize resulted in 20.23,17.60 and 25.13 ppm deposits on leaves. The residues of endosulfan and malathion reached below the tolerance level in 3 and 1 day on leaves and in 3 and 1 day on cob husk respectively. The deposits and residues of carbaryl were below tolerance level at any stage of the corn plants. The half-life values for endosulfan, carbaryl and malathion were 4.36, 3.91 and 0.19 days on leaves and 0.86,1.83 and 0.15 days on cob husk. However, the residues of all the three insecticides in maize grain were below detectable level.

INTRODUCTION

The maize which is an important cereal crop, is attacked by borers, armyworms and aphids (TREHAN & BUTANI, 1949; SRIVASTAVA 1959; KUSHWAHA & JAIN, 1966; NOOR, 1969). There are several insecticidal recommendations available, but lately, GREWAL (1969) reported that endosulfan, fenitrothion, monocrotophos and trichlorphon were quite effective in controlling maize borer. DUTTA (1970) also found carbaryl giving good control of maize borer. Spraying of malathion for the control of aphids appearing at the later stage of maize growth is also suggested. In order to determine the possible contamination of the maize crop with insecticides particularly from the consumers' safety point of view, studies have been conducted to estimate the micro-quantities of enosulfan, carbaryl and malathion in/on maize leaves, cob husk and grain.

MATERIALS AND METHODS

Maize was sown on 22 July, 1976 in plots measuring 3 × 3 m^2 at the Agronomy Farm, Rajasthan College of Agriculture, Udaipur. The distance between plant to plant and row to row was kept as 15 and 70 cm. Recommended concentrations of insecticides, endosulfan (0.04%) EC, carbaryl (0.2%) sevimol 40LV and malathion (0.05%) EC were sprayed at the rate of 1000 l per h.a. when the plants were 60 days old. There were, thus four treatments including control and each was replicated three times.

Plant samples (leaves, cob husk, grains etc.) were collected in triplicate at intervals of 0,1,3,5,7,15,21 and 31 days until harvest. The samples were chopped to small pieces and were extracted by tumbling over a motorised shaker for half an hour with *n*-hexane, methylene chloride and carbon tetrachloride for endosulfan, carbaryl and malathion residues, using each of the solvent at the rate of 8 ml per g sample.

The residues of endosulfan were estimated according to the procedure of MAITLEN *et al.* (1963) incorporating the cleanup technique given by KATHPAL & DEWAN (1975). Residues of carbaryl and malathion were estimated using spectrophotometric technique of BENSON & FINOCCHIARO (1965) and Malathion Panel (1960) respectively.

RESULTS AND DISCUSSION

Residues of endosulfan

The spray of 0.04% endosulfan resulted in an average 20.23 ppm deposit on maize leaves (Table 1) which dissipated by about 4.5, 73.5, 92.7, 99.9 and 100.0 per cent in

TABLE 1. Mean residues of different insecticides in/on maize leaves.

Days after application	Residues in ppm of different insecticides		
	Endosulfan	Carbaryl	Malathion
0	20.23	27.60	25.13
1	19.33 (4.45)	22.00 (18.11)	1.10 (95.62)
3	7.17 (64.55)	20.00 (27.53)	0.03 (99.88)
5	5.37 (73.45)	17.00 (38.40)	BDL (100.00)
7	5.17 (74.44)	9.80 (64.49)	
11	4.13 (79.58)	2.13 (92.28)	
15	1.43 (92.93)	0.93 (96.63)	
21 (At harvest)	0.03 (99.85)	0.13 (99.89)	
31 (Dry leaves)	BDL (100.00)	BDL (100.00)	
Half-life (days)	4.36	3.91	0.19

Figures in parenthesis are percentage reduction: BDL—below detectable level.

1, 5, 15, 21 and 31 days respectively. The residues at 21 days were found to be 0.03 ppm and below detectable level at 31 days. On cob husk, the residues were only 11.33 and 0.27 ppm, 1 and 3 days after spray and were lost below detectable level in 7 days (Table 2). No residues could be detected in grains (milkystage and dry grains). These results suggest that the residues of endosulfan reached below tolerance level of 2 ppm (FAO, 1972) in 15 days on treated leaves and 3 days on treated husk. DESHMUKH & JOIA (1971) also reported that endosulfan persisted upto 25 days on maize leaves but its residues in ripening grain and fodder at harvest were below tolerance level.

TABLE 2. Mean residues of different insecticides in/on maize cob husk.

Days after application	Residues in ppm of different insecticides		
	Endosulfan	Carbaryl	Malathion
0	14.66	21.27	19.53
1	11.33 (20.46)	12.43 (41.56)	0.23 (98.82)
3	1.47 (89.97)	6.00 (70.94)	BDL (100.00)
5	0.27 (98.15)	3.07 (85.57)	
7	BDL (100.00)	0.07 (99.67)	
11		BDL (100.00)	
Half-life (days)	0.86	1.83	0.15

Figures in parenthesis are percentage reduction; BDL—below detectable level.

Residues of carbaryl

The average deposits of 27.60 ppm from a 0.2 per cent spray of carbaryl on maize degraded from the leaves by 18.11 per cent in one day, 30.40 per cent in 5 days and more than 90 per cent in 11 days. The residues found 21 days after application was 0.13 ppm, and below detectable level at 31 days. In case of cob husk the carbaryl deposit of 21.27 ppm was reduced to the extent of 41.56, 70.94, 85.57, 99.67 and 100.0 per cent in 1, 3, 5, 7 and 11 days. The residues in grain at all the interval were found to be below detectable level. The half-life value of carbaryl on leaves was 3.91 days and cob husk 1.83 days. The deposits and residues at any stage were below the tolerance levels prescribed (FAO, 1974). DESHMUKH & SARAMMA (1971) found that though there was 15–28 per cent reduction of carbaryl residues from maize leaves within 24 hours the residues persisted for 20 days under field conditions. However,

they found that the residues reached below tolerance level within 15 days.

Residues of malathion

The initial deposit from the spray of malathion was 25.13 ppm on maize leaves and 19.53 ppm on cob husk. The residues dissipated below tolerance level of 8 ppm (FAO, 1972) within 24 hours of spraying and reached below detectable level within 3–5 days in both the cases. In grains at milky stage even immediately after spraying the residues were below detectable level. The half-life of malathion on leaves and cob husk was found to be 0.19 and 0.15 days respectively. JAT *et al.* (1971) also found in experiments here that the residue of 0.1 per cent malathion emulsion spray on okra fruits reached below 3 ppm within 2 days and below detectable level within 5 days.

Acknowledgements:– Authors are thankful to the Associate Director (Research) and Professor and Head, Department of Entomology, Rajasthan College of Agriculture, University of Udaipur, Udaipur for providing necessary facilities during the course of these investigations.

REFERENCES

BENSON, W. R. & J. M. FINOCCHIARO (1965) Rapid procedure for carbaryl residues estimation: Modification of official colorimetric method. *J. Ass. off. agric. Chem.*, **48** : 676-679.

DESHMUKH, S. N. & B. S. JOIA (1971) Endosulfan and Fenitrothion residues in/on maize, 93–97, *in: Progress and Problems of Pesticide Residue Analysis* (ed. BINDRA, O. S. & R. L. KALRA), Punjab Agric. Univ., Ludhiana, and Indian Council of Agricultural Research, New Delhi.

DESHMUKH, S. N. & P. U. SARAMMA (1971) Dissipation of carbaryl residues on maize, 98–101, *in: Progress and Problems of Pesticide Residue Analysis* (ed. BINDRA, O. S. & R. L. KALRA)., Punjab Agric.–Univ., Ludhiana, and Indian Council of Agricultural Research, New Delhi.

DUTTA, S.C. (1970) Studies on the effectiveness of DDT, endrin and carbaryl against *Chilo zonellus* (SWINHOE) along with residues of DDT and endrin in/on maize. Thesis submiteted to the Punjab Agricultural University, Ludhiana for the degree of the Master of Science in Entomology.

F. A. O. (1972) Pesticide residues in Food. *FAO Agricultural Studies*, **88** : 30–34.

F. A. O. (1974) Pesticide residues in Food. *FAO Agricultural Studies*, **92** : 30.

GREWAL, C. S. (1969) Chemical control of maize-borer, *Chilo zonellus* (SWINHOE) (Crambidae: Lepidoptea). Thesis submitted to the Punjab Agricultural University, Ludhiana for the degree of Master of Science in Entomology.

JAT, N. R., B. P. SRIVASTAVA & H. C. L. GUPTA (1971) Dissipation of malathion residues in fruits of bhindi, *Abelmoschus esculentus* MOENCH, 109, *in : Progress and Problems of Pesticide Redsidue Analysis* (ed. BINDRA, O. S. & R. L. KALRA), Punjab Agric.–Univ., Ludhiana, and Indian Council of Agricultural Research, New Delhi.

KATHPAL, T. S. & R. S. DEWAN (1975) Improved cleanup technique for the estimation of endosulfan and endrin residues. *J. Ass. off. agric. Chem.*, **58** : 1076–1080.

KUSHWAHA, K. S. & S. K. JAIN (1966) On some forage insect pests of Rajasthan, 404–410, *in : Proceedings of 2nd All India Congress Zoology, Varanasi*, (1962).

MAITLEN, K. N., K. C. WALKER & W. E. WESTLAKE (1963) An improved colorimetric method for determining endosulfan (Thiodan) residues in vegetable and beaf fat. *J. agric. Fd. Chem.*, **11** : 416–418.

MALATHION PANEL (1960) Report on recommended methods of analysis of pesticide residues in food stuffs. Determination of malathion residues in cereals and oilseeds. *Analyst*, **85** : 915–921.

NOOR, A. (1969) Evaluation of insecticidal control schedule against insect pests of maize (Hybrid 'Ganga–3'). Thesis submitted to the University of Udaipur, Udaipur for the degree of Master of Science in Entomology.

SRIVASTAVA, B. K. (1959) Insect pest of maize in Rajasthan. *J. Bombay nat. Hist. Soc.*, **56** : 665–668.

TREHAN, K. N. & D. K. BUTANI (1949) Notes on life history, bionomics and control of *Chilo-zonellus* (SWINHOE) in Bombay Province. *Indian J. Ent.*, **11** : 47–59.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 161 *to* 162

RESIDUES OF ENDOSULFAN IN CLAY LOAM SOIL

H. C. L. GUPTA, B. L. PAREEK & K. P. SHARMA
Department of Entomology, College of Agriculture, University of Udaipur,
Udaipur, India 313001

(*Received 12 May 1977*)

The application of endosulfan granules in clay loam soil at 1 and 3 kg a.i. per hectare resulted in the deposits of 0.8–1.0 ppm and 2.5–2.9 ppm respectively. The residues of endosulfan persisted for longer period in case of furrow application as compared to broadcasting. However, the residues were below detectable level at 60 days interval even from the application dosages of 3 kg when applied as granules.

INTRODUCTION

The chlorinated hydrocarbon insecticides like DDT, BHC, aldrin, heptachlor, dieldrin and chlordane are usually recommended for the control of soil inhabiting insects (REDDY, 1968; BANERJEE, 1970) because of their longer persistence and high toxicity. There are reports of absorption and translocation of residues of these soil insecticides in edible parts of the plants (SINGH & KALRA, 1971; ATTRI *et al.*, 1976; GUPTA *et al.*, 1977). In view of substituting these longer persistent insecticides, a trial was conducted using endosulfan in soil because of its high biological effectiveness and comparatively lesser persistence in nature.

MATERIALS AND METHODS

The application of endosulfan 4 G was done at the rate of 1 and 3 kg a.i. per hectare in clay loam soil. There were 15 plots each measuring 3.0 × 2.5 m. The granules were applied by two different methods *viz.*, broadcasting and furrow application. In case of broadcasting the granules were mixed up in 8–10 cm top soil. After preparing furrows at a distance of 70 cm the granules were applied in them and covered with soil. In this way, there were 5 furrows per plot.

The soil samples were collected at regular interval from 8–10 cm deep soil by an auger at random from five spots of a plot. They were pooled together, mixed homogeneously and quartered to the required size. The extraction of endosulfan from soil was done using *n*-hexane+isopropanl (2+1) at 2 ml per g as solvent by tumbling over a motorised shaker for half an hour. The cleanup and analysis of the extract was done according to the improved method described by KATHPAL & DEWAN (1975). It was possible to recover 93% of endosulfan from the fortified samples.

RESULTS AND DISCUSSION

The treatment dosage of 1 kg a.i. per hectare in clay loam soil resulted in the deposit of 0.76–0.95 ppm in both the application methods. There was rapid reduction of endosulfan residues from the broadcasting treatment than that of furrow application. The persistence of residues was for 30 days in case of broadcasting and 45 days in case of furrow application (Table 1). It is evident from Table 2 that the deposit of 2.5 ppm resulted from 3 kg a.i. per hectare treatment dosage dissipated by about 63,70,87 and 100 per cent after 8, 15, 30 and 45 days in case of broadcasting treatment. There was rather slower dissipation of residues in furrow application which comprised of about 50, 55, 59, 78 and 100 per cent after 8, 15, 30, 45 and 60 days of application.

It can thus be concluded that persistence of endosulfan residues in clay loam soil

TABLE 1. Persistence of endosulfan (1 kg a.i. per hectare) in soil (Mean of three replications).

Days after treatment	Broadcasting		Furrow application	
	Residue (ppm)	Reduction (%)	Residue (ppm)	Reduction (%)
0	0.76	..	0.95	..
8	0.41	46.53	0.64	32.63
15	0.25	67.10	0.36	62.10
30	BDL	100.00	0.11	88.42
45	BDL	100.00	BDL	100.00

BDL—below detectable level.

TABLE 2. Persistence of endosulfan (3 kg a.i. per hectare) in soil (Mean of three replications).

Days after treatment	Broadcasting		Furrow application	
	Residue (ppm)	Reduction (%)	Residue (ppm)	Reduction (%)
0	2.51	..	2.89	..
8	0.93	62.94	1.44	50.16
15	0.76	69.72	1.31	54.66
30	0.32	87.25	1.19	58.82
45	BDL	100.00	0.54	77.85
60	BDL	100.00	BDL	100.00

BDL—below detectable level

from both the application dosages and both the application methods was not more than 60 days. However, there was rapid dissipation of residues from broadcasting treatment as compared to furrow application. This may be due to more area given for the exposure of residue to the environment as well as to the micro-organism present there in case of broadcasting treatment. Hence, it may be presumed that the crops, if raised on endosulfan treated soil, will not contain the residue after 60 days of application.

Acknowledgements:- The authors are thankful to Professor and Head, Department of Entomology and to the Associate Director (Research), College of Agriculture, University of Udaipur, Udaipur for providing facilities to carry out this study.

REFERENCES

ATTRI, B. S., R. LAL, R. S. DEWAN & S. Y. PANDE (1976) Residues of aldrin in potato. *Entomon*, **1** : 55–58.

BANERJEE, S. N. (1970) Science in Practice: Pest and disease number. *Pl. Prot. Bull.*, New Delhi, **11** : 31–32.

GUPTA, H.C.L., K.S. KUSHWAHA, V.S. KAVADIA & B. P. SRIVASTAVA (1977) Uptake of aldrin residues in root crops from treated soils, 38–39, *in*: *Abstracts of Symp. on Insects and Environment* Feb., 21–23, 1977, University of Delhi, Delhi.

KATHPAL, T. S. & R. S. DEWAN (1975) Improved cleanup technique for the estimation of enosulfan and endrin residues. *J. off. agric. chem.*, **58**: 1076–1080.

REDDY, D. B. (1968) *Plant Protection in India*. Allied Publishers Pvt. Ltd., New Delhi, 165pp.

SINGH, T. & R. L. KALRA (1971) Aldrin and dieldrin residues in potatoes. *Proc. SPRA* : 137–139.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 163 *to* 164

EFFECT OF TLCV INFECTION ON *BEMISIA TABACI*

N. S. BUTTER AND H. S. RATAUL
Department of Entomology, Punjab Agricultural University,
Ludhiana, India

(*Received 27 April 1977*)

The tomato leafcurl virus (TLCV) is transmitted by whitefly, *Bemisia tabaci* GENNADIUS. The virus infection reduced the fecundity and fertility of the whitefly but no effect could be observed on the longevity of both the sexes of adult whiteflies.

INTRODUCTION

The whiteflies in addition to being pests, are very important as vectors of viruses known to cause several severe diseases in a number of crops. VARMA (1963) gave a list of 28 plant diseases caused by whitefly-borne viruses in the world. In none of the studies carried out by earlier workers the effect of virus on the fertility and fecundity of whitefly vectors was reported. Therefore studies were initiated at Punjab Agricultural University, Ludhiana to ascertain the effect of virus on he vector, *Bemisia tabaci* GENNADIUS.

MATERIALS AND METHODS

The whitefly, *Bemisia tabaci* GENNADIUS was reared on both healthy tomato plants as well as on plants infected with tomato leafcurl virus. The freshly emerged whiteflies from the viruliferous and non-viruliferous colonies were released in pairs (one male and one female) on healthy tomato leaves in the leaf-cages (BUTTER, 1976). These whiteflies were sexed on structural differences based on the shape and size of the abdomen and size of wings (PRUTHI & SAMUEL, 1942; COSTA & BENNETT, 1950). Twenty such pairs from each colony were used to study the fecundity and longevity. The leaf-cages having male and female were put on the new leaves. The leaves having the eggs on them were examined under binocular microscope. The death of each whitefly in a group was noted. Whenever the male died it was replaced to ensure maximum fecundity of the female. Similarly another 20 pairs from each of the colonies were taken to study the fertility of the females. The whiteflies were allowed to lay eggs on the under surface of the leaves in the leaf-cages. Equal number of eggs taken from both the viruliferous and non-viruliferous colonies were kept for hatching. The whitefly in pairs were tansferred to new leaves after three days. The nymphs that hatched out from the eggs were recorded in each case. The nymphs and pupae were removed daily with the help of a needle. In comparing the fecundity, fertility and longevity of the adults from viruliferous and non-viruliferous colonies of whiteflies, the paired 'T' test was used.

RESULTS AND DISCUSSION

The results (Table 1) show that on an average the female from the viruliferous and non-viruliferous colonies laid 51.05 and 68.05 eggs, respectively. The mean fertility of the females from the viruliferous and non-viruliferous colonies was 35.60 and 56.80 nymphs/pupae, respectively. The difference as showed by paired 't' test between fecundity and fertility of females from both the colonies was significant at five per cent level. However the test indicated that the differences in the longevity of two sexes from both the colonies were not significant. It appeared from the data that the virus infection reduced the fecundity and fertility of whiteflies but the longevity of whiteflies was not in any way influenced by the virus infection.

TABLE 1. Mean fecundity, fertility and longevity of whiteflies obtained from the viruliferous and non-viruliferous colonies.

Fecundity		Fertility		Longevity (days)			
Viruliferous	Non-viruliferous	Viruliferous	Non-viruliferous	Viruliferous		Non-viruliferous	
				Female	Male	Female	Male
51.05	68.05	35.60	56.80	15.25	3.65	15.25	3.45

	S D	Observed 't' value
Fecundity	27.19	2.64*
Fertility	16.37	5.98*
Longevity		
(a) female	1.37	1.66 NS
(b) male	1.44	0.31 NS

Acknowledgements:– The authors are thankful to Miss LOUSIE RUSSELL, U. S. Department of Agriculture, for the identification of whitefly species.

REFERENCES

BUTTER, N. S. (1976) Studies on the virus-vector relationship of tomato leafcurl virus and its vector *Bemisia tabaci* GEN. Unpub. Ph. D. thesis, Punjab Agric. Univ., Ludhiana.

COSTA, A. S. & C. W. BENNETT (1950) Whiefly transmitted mosaic of *Euphorbia prunifolia*. *Phytopathology*, **40**: 226–233.

PRUTHI, H. S. & C. K. SAMUEL (1942) Entomological investigation on the leafcurl disease of tobacco in northern India. V. Biology and population of whitefly vector (*B. tabaci* GEN.)) in relation to the incidence of the disease. *Indian J. agric. Sci.*, **12** : 35–57.

VARMA, P. M. (1963) Transmission of plant viruses. *Bull. natn. Insti. Sci. India*, **24**: 11.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 165 *to* 169

STOMODAEAL AND CENTRAL NERVOUS SYSTEMS OF THE LARVA OF *TROGODERMA GRANARIUM* EVERTS (COLEOPTERA : DERMESTIDAE)

SHASHI GUPTA[1], SUDHIR BHARGAVA[2] & HARI C. AGARWAL
Department of Zoology, University of Delhi,
Delhi, India 110007

(*Received 27 April 1977*)

The stomodacal nervous system of the last instar larva of *Trogoderma granarium* EVERTS consists of a frontal ganglion with its nerves, recurrent nerve, and a paired corpus cardiacum-allatum (cc-ca) complex. The central nervous system comprises the brain, suboesophageal ganglion, three thoracic ganglia and 6 abdominal ganglia. Histologically, cc-ca complex can be differentiated into anterior corpus cardiacum and a posterior corpus allatum.

INTRODUCTION

The stomodaeal nervous system of insects possesses a dual function as it innervates the organs arising from the embryonic stomodaeum and is also an important centre of endorcrine activity. The possible role of the stomodaeal nervous system in the larval and pupal diapause has been indicated by several workers (YIN & CHIPPENDALE, 1973; NASR, 1974).

Trogoderma granarium EVERTS, a serious pest of stored wheat, exhibits a weak facultative larval diapause (BURGES, 1959). The regulatory mechanism of diapause for this insect is not known. The neurosecretory cells/endocrine glands are likely to play a significant role in this diapause. A prerequisite for studies on the role of these is a thorough understanding of the anatomy and morphology of the stomodaeal nervous system and the central nervous system. Because of these reasons, the stomodaeal and central nervous systems of *T. granarium* larva were studied.

[1] Recipient of Junior Research Fellowship of University Grants Commission, New Delhi.

[2] Teacher Fellow, Centre of Advance Study from Government College, Ajmer, Rajasthan.

MATERIALS AND METHODS

Last instar larvae of *T. granarium* were taken from cultures maintained in this laboratory, at 35±1°C on broken wheat and 5% brewers yeast. Freshly killed larvae were dissected in water under a stereoscopic binocular microscope. Methylene blue was applied to the dissected larvae to study the organs and the associated nerves. Stain was allowed to act for a few seconds and subsequently washed. Sections of retrocerebral complex along with the brain were cut at 5–7 μ and stained with paraldehyde fuchsin (EWEN, 1962).

RESULTS

The stomodaeal nervous system

The stomodaeal nervous system of the last instar larva of *Trogoderma* consists of the frontal ganglion and its nerves and the corpus cardiacum-allatum complex (Fig. 1). The frontal ganglion is situated in front of the brain on the anterodorsal surface of the pharynx as a small oval ganglion and it is connected to the brain by a pair of very short frontal connectives (Fig. 2). The frontal connectives arise from the common labro-frontal nerve. From anterior and lateral sides of the frontal ganglion, slender

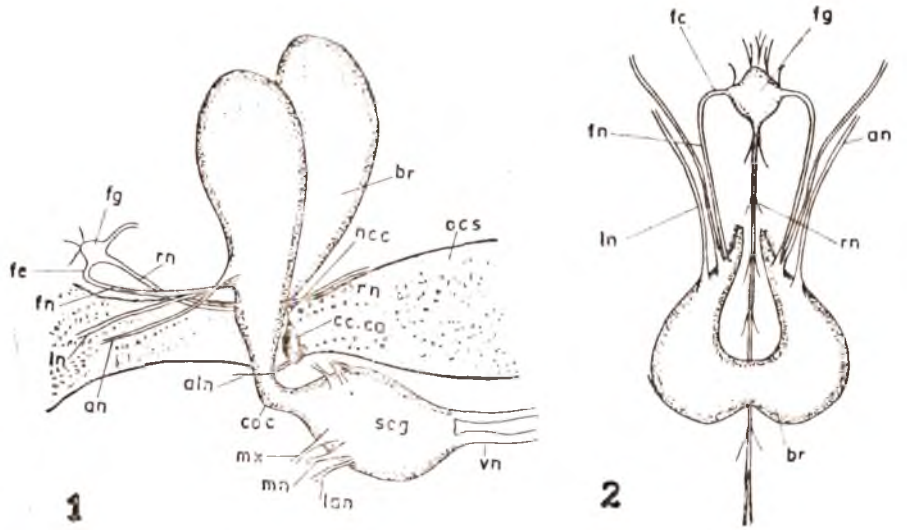


Fig. 1. The stomodaeal nervous system, brain and suboesophageal ganglion, lateral view.
Fig. 2. Frontal ganglion and its nerves, dorsal view.

nerves originate to innervate the pharyngeal area. The frontal ganglion narrows posteriorly into a median trunk, the recurrent nerve. This runs on the dorsal side of the oesophagus with aorta above it. After running for some distance over oesophagus it terminates with fine nerve endings posterior to corpus cardiacum-allatum complex (cc-ca complex). Two pairs of nerves arise from the recurrent nerve to supply the walls of the oesophagus. However, no connection of frontal ganglion with the protocerebrum could be seen.

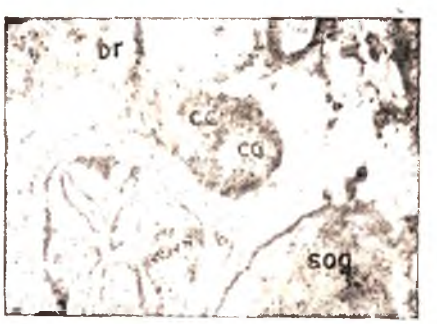


Fig. 3. Photomicrograph showing the corpus cardiacum-allatum complex (×250).

Corpus cardiacum-allatum complex: In *Trogoderma* larva the corpus cardiacum and allatum of each side are fused to form a single complex. The complex is divided into two portions morphologically when seen under the microscope, an anterior bluish white portion, the corpus cardiacum and a posterior translucent region, the corpus allatum (Fig. 3). Each cc-ca complex is narrow, elongated and closely associated with oesophagus. It is present below the root of the nerves from the tritocerebrum of the brain. Only one pair of nervi corpori cardiacii could be seen in this study. Externally, fusion of the corpus cardiacum and allatum is complete and the complex gives no indication of dual composition. From the corpus allatum portion a single allatal nerve arises. Histologically, the complex can be clearly differentiated into anterior corpus cardiacum and a posterior spherical corpus allatum (Fig. 3). The line of de-

marcation between them is very clear. The corpus cardiacum portion may be further differentiated into two parts, the anterior part with secretory cells and a posterior storage lobe with interstitial cells. The corpus allatum portion also shows secretory cells which are larger in size and closely packed.

The central nervous system

The central nervous system consists of the brain, the suboesophageal ganglion, three thoracic ganglia, six abdominal ganglia and the nerves originating from them (Fig. 4).

Brain: The brain is bilobed and tapers anteroventrally. The protocerebrum is the most prominent portion while the deuto- and trito-cerebrum form the smaller portion. The antennal nerves originate from the deuto-cerebrum and the labro-frontal nerves from the tritocerebrum. The circumoesophageal connective is thick and short. It encircles the oesophagus and connects the brain with suboesophageal ganglion.

Sub-oesophageal ganglion: It is a round and dorsoventrally flattened ganglion situated ventral to the brain. From its antero-lateral sides three pairs of nerves originate. The first one is a stout nerve which runs towards the anterior side to innervate the maxilla. The second nerve posterior to the first also runs in the same direction to innervate the mandibles. The third is the labial nerve which innervates the labial palps. All these nerves divide into finer branches on the surfaces of these organs. Posterior part of the ganglion

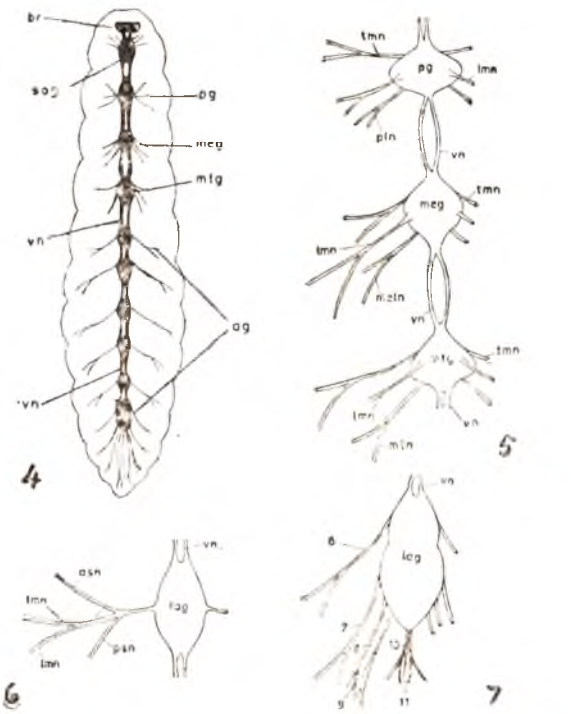


Fig. 4. Central nervous system *in situ*. Fig. 5. Thoracic ganglia and their nerves. Fig. 6. Typical abdominal ganglion and its nerves Fig. 7. Last abdominal ganglion and its nerves.

ABBREVIATIONS USED IN FIGURES

ag — Abdominal ganglion; aln — Allatal nerve; an — Anterior segmental nerve ; ao — Aorta; asn — Anterior segmental nerve; br — Brain; ca — Corpus allatum ; cc — Corpus cardiacum; cc-ca—Corpus cardiacum-allatum complex; coc—Circum-oesophageal connective; fc—Frontal connective; fg — Frontal ganglion; fn — Frontal nerve; lag — Last abdominal ganglion; lan — Labial nerve; lmn — Longitudinal muscle nerve; ln — Labral nerve; mn — Mandibular nerve; meg — Mesothoracic ganglion; meln — Mesothoracic leg nerve; mtg — Metathoracic ganglion; mtn—Metathoracic leg nerve; mx — Maxillary nerve; ncc—Nervi corpori cardiacii; nsm—Neurosecretory material; oes—Oesophagus; pg — Prothoracic ganglion; pln — Prothoracic leg nerve; psn — Posterior segmental nerve; rn — Recurrent nerve; sog — Suboesophageal ganglion; tag — Typical abdominal ganglion; tmn — Transverse muscle nerve; vn — Ventral nerve cord; 6 — Nerve to sixth abdominal segment; 7 — Nerve to seventh abdominal segment; 8 —Nerve to eighth abdominal segment; 9 — Nerve to ninth abdominal segment; 10 — Lateral nerve; 11 — Median nerve.

narrows down to form the double ventral nerve cord.

Thoracic ganglia: In the thorax, three ganglia are situated (Fig. 5). From each of these ganglia, three pairs of nerves originate to innervate the muscles and legs. First nerve which originates from ventro-antero-lateral part of the ganglion innervates the transverse muscles of the segment with finer branches. Posterior to it, the nerves originate from dorso-mid-lateral region to innervate the longitudinal muscles of the segment. The third nerve which originates from the ventro-postero-lateral region, is a stout nerve and innervates the leg.

Abdominal ganglia: There are six abdominal ganglia. The first five are similar in shape and number of nerves originating from them. The sixth or the last abdominal ganglion is bigger than the first five ganglia. First five abdominal ganglia (Fig. 6) are situated in the first to fifth abdominal segments and give out a single pair of nerves from the mid-lateral region. This nerve after running for some distance divides into three branches. The first branch goes to the segment anterior to the ganglion while the second one runs further for a short distance and then divides into two branches, one for the transverse and another for the longitudinal muscles of the segment. The third branch runs towards the part of the segment posterior to the ganglion. The last abdominal ganglion is a bilobed structure with a median fissure (Fig. 7). This ganglion is situated in the sixth abdominal segment and sends nerves to the sixth, seventh, eighth and ninth abdominal segments. All these nerves after running for a short distance in their respective segment divide into branches to innervate longitudinal and transverse muscles. From the mid-posterior region three nerves originate. The two lateral ones innervate the posterior region of the alimentary tract while the median one innervates the last segment with fine branches.

DISCUSSION

In the present paper the anatomy of the stomodaeal and central nervous systems has been described in the last instar larva of *T. granarium*. The corpus cardiacum and allatum of each side are fused to form a single structure. Histologically, however, the two can be differentiated. In coleopteran larvae like *Ctenicera aeripennis destructor* the corpora allata have been described but no mention is made of corpora cardiaca (EIDT, 1958). It is not clear if the corpus allatum is actually a fused corpus allatum-cardiacum complex as in *Trogoderma* larva or not. In the adult *Dermestes maculatus*, the corpus allatum and cardiacum are separate structures (LADDUWAHETTY, 1968).

In *Trogoderma* larva only a single nerve could be traced connecting the corpus cardiacum-allatum complex with the brain as also reported in the douglas fir beetle, *Dendroctonus pseudotsugae* (ATKINS & CHAPMAN, 1957). This could be due to the fusion of the two nerves (CAZAL, 1948). The allatum portion of the complex sends only one nerve which could not be traced far. In comparison to this, YIN & CHIPPENDALE (1973) have reported two nerves in a lepidopterous larva, one innervating the mandibular region and the other the maxillary region.

The gross morphology of the central nervous system of the last instar larva of *Trogoderma* is on the same plan as described for other coleopterous larvae (CAZAL, 1948; AREEKUL, 1957; EIDT, 1958; BERBERET & HELMS, 1972). *Trogoderma* larva has three thoracic ganglia as in most of the coleopterous larvae. However, the larva of *Oryctes rhinoceros* has only a pro- and a mesothoracic

ganglion. The mesothoracic ganglion is partially fused with the common metathoracic abdominal ganglion (AREEKUL, 1957). The thoracic ganglia in the larvae of some scarabaeidae (AREEKUL, 1957) and *C. aeripennis destructor* (EIDT, 1958) give off two pairs of nerves whereas in *Trogoderma* there are three pairs of nerves arising from each thoracic ganglion. Generally, the thoracic ganglion gives off two to three pairs of nerves in insect larvae (SNODGRASS, 1935).

The number of abdominal ganglia varies greatly in coleopteran larvae. In *Trogoderma*, there are six abdominal ganglia, the sixth one being a composite one for the sixth to ninth segments. In insects like *Phyllophaga anxia* (BERBERET & HELMS, 1972) and *C. aeripennis destructor* (EIDT, 1958) there are eight abdominal ganglia. In *Polyphylla* all the abdominal ganglia are fused together (AREEKUL, 1957). In scolytid beetles also they are fused into one which indicates a high degree of specialization (ATKINS & CHAPMAN, 1957). In the larvae of cyclorrhaphous Diptera, extreme condensation is attained in which the entire ventral nerve cord, including the suboesophageal ganglion is consolidated into an elongate mass of nerve tissue, from which the entire body is innervated (SNODGRASS, 1935). In *Trogoderma* each abdominal ganglion except the sixth, gives off one pair of nerves as in some scarabaeidae (AREEKUL, 1957). In *C. aeripennis destructor* each abdominal ganglion gives off two pairs of nerves (EIDT, 1958).

REFERENCES

AREEKUL, S. (1957) The comparative internal larval anatomy of several genera of Scarabaeidae (Coleoptera). *Ann. ent. Soc. Am.*, **50**: 562–577.

ATKINS, M. D. & J. A. CHAPMAN (1957) Studies on nervous system anatomy of the douglas fir beetle, *Dendroctonus pseudotsugae* HOPK. (Scolytidae). *Can. Ent.*, **89**: 80–86.

BERBERET, R. C. & T. J. HELMS (1972) Comparative anatomy and histology of selected systems in larval and adult *Phyllophaga anxia* (Coleoptera: Scarabaeidae). *Ann. ent. Soc. Am.*, **65** : 1026–1053.

BURGES, H. D. (1959) Dormancy of the khapra beetle. Quiescence or diapause. *Nature, Lond.*, **184** : 1741–1742.

CAZAL, P. (1948) Les glandes endocrines retrocerebrales des insectes. *Bull. biol. Fr. Belg. Suppl.*, **32** : 1–227.

EIDT, D. C. (1958) Anatomy and histology of the full grown larva of *Ctenicera aeripennis destructor* (BROWN) (Coleoptera : Elateridae). *Can. J. Zool.*, **36** : 317–359.

EWEN, A. B. (1962) An improved aldehyde fuchsin staining technique for neurosecretion products by insects. *Trans. Am. microsc. Soc.*, **81**: 94–96.

LADDUWAHETTY, A. M. (1968) The neuro-endocrinal basis of oviposition in *Dermestes maculatus* DEGEER. I. The neurosecretory system. *Ceylon J. Sci. biol, Ser.* **8** : 11-20

NASR, H. A. (1974) Studies on the role of the endocrine complex on diapause development of *Ostrinia nubilalis* (Lepidoptera : Pyralidae). *Z. angew. Ent.*, **76** : 137–143.

SNODGRASS, R. E. (1935) *Principles of Insect Morphology*, McGraw Hill, New York, 646 pp.

YIN, C. M. & G. M. CHIPPENDALE (1973) Endocrine system of mature diapause and non-diapause larvae of the south-western corn borer, *Diatraea grandiosella*. *Ann. ent. Soc. Am.*, **66** : 943–947.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 171 *to* 174

'RETOURNEMENT' OF THE AEDEAGUS IN BRUCHIDAE (COLEOPTERA, PHYTOPHAGA)

B. L. PAWAR & K. K. VERMA[1]
Department of Zoology, J. H. Government College, Betul, M. P., India

(*Received 20 February 1977*)

Six species of Bruchidae have been examined for the nature of the tracheal and nervous supply for the aedeagus and in all 'retournement' has been inferred. In *Callosobruchus jekeli* the 'retournement' occurs equally readily in clockwise and anticlockwise directions, while in the other species examined it is clockwise.

INTRODUCTION

In some Coleoptera the aedeagus undergoes during development a turning about its longitudinal axis; the rotation is independent of the terminal abdominal segments. The phenomenon has been called "retournement' of the aedeagus by JEANNEL (1955). One of the present authors (K. K. V.) has preferred continued use of the term 'retournement' for want of a suitable English equivalent. The ontogenetic rotation of the aedeagus leads to a twisted tracheal and nervous supply for the organ (JEANNEL, 1955; VERMA, 1969). KUMAR & VERMA (1971) have studied tracheal and nervous supply for the aedeagus in several members of Chrysomelidae and have found the supply invariably twisted and such that 'retournement' of the aedeagus may be inferred. Bruchidae is closely related to Chrysomelidae; familial separation of the two has been regarded as unjustifiable (CROWSON, 1960). KINGSOLVER'S (1970) study of aedeagal musculature in Bruchidae shows a general resemblance to that of Chrysomelidae. Hence 'retournement' of the aedeagus in Bruchidae was suspected.

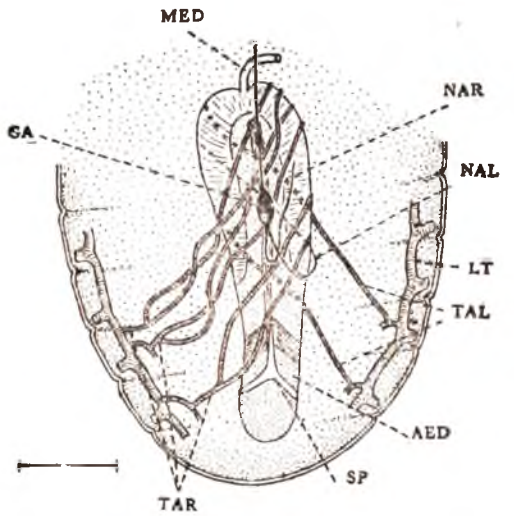
[1] Present address: Department of Zoology, Government Arts and Science College, Durg, M. P., India.

MATERIALS AND METHODS

Adult males of *Bruchus pisorum* L., *Caryedon gonagra* F., *Euspermophagus convolvuli* THUMB., *Callosobruchus maculatus* F., *C. jekeli* ALLIB., and *C. chinensis* L. were dissected from the ventral side after affixing to wax, so as to expose nerves and tracheae reaching the base of the aedeagus. Material was collected from October 1975 to March 1976 and in all cases fresh specimens were dissected. More than ten males of each species were examined.

OBSERVATIONS

In all the six species, except *C. jekeli*, the tracheal and nervous supplies reaching the base of the aedeagus are twisted suggesting a turning of the aedeagus through about 180° in the clockwise direction, when seen from behind. Thus the tracheae for the aedeagus arising on the right side run forward, obliquely passing beneath the aedeagus to reach the base of the organ on the left side. The aedeagal tracheae arising on the left side pass dorsal to the aedeagus to reach the aedeagus base on the right side. Similarly the left aedeagal nerve arising from the last abdominal ganglion crosses over to the opposite side, passing obliquely dorsal to the aedeagus to reach the aedeagus base on the right side. The right aedeagal nerve forms a loop on the under surface of the aedeagus before entering the aedeagus on the left side (Figs. 1 to 5).



Figs. 1–6. Abdomens of bruchid males, dissected from the ventral side to expose the tracheal or nervous supply to the aedeagus or both. The scale accompanying each figure denotes 0.5 mm.

Fig. 1. *Bruchus pisorum*, showing both tracheal as well as nervous supply for the aedeagus.

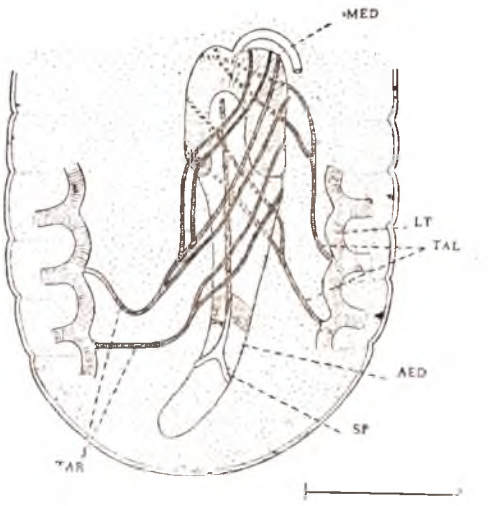


Fig. 3. *C. chinensis*, showing the tracheal supply for the aedeagus.

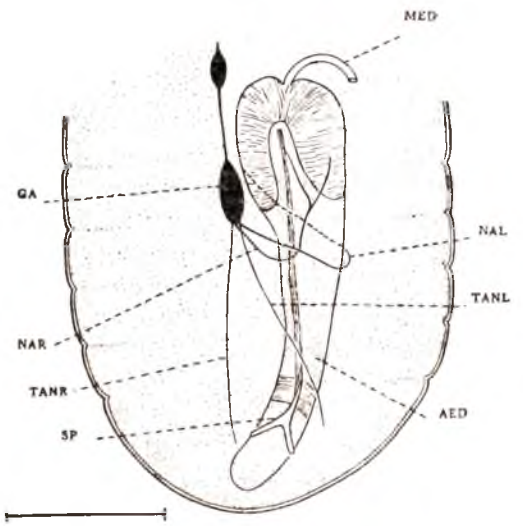


Fig. 2. *Callosobruchus chinensis*, showing the nervous supply for the aedeagus.

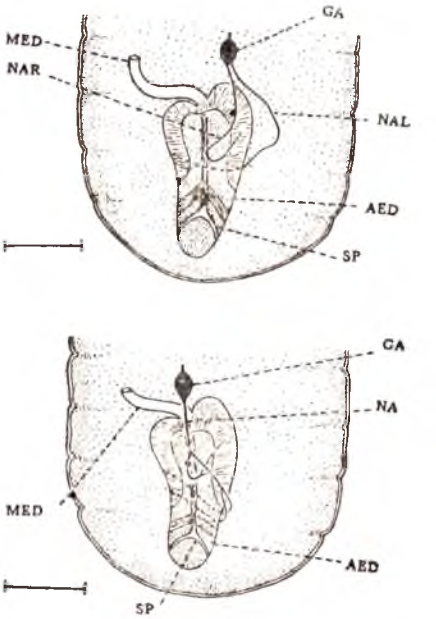


Fig. 4. (above) *C. maculatus*, showing the nervous supply for the aedeagus; Fig. 5. (below) *C. maculatus*, showing the basal fusion of the aedeagal nerves.

In *C. maculatus* the aedeagal nerves are variable in that they may be free at the origin from the ganglion or they may be fused for a variable distance from the ganglion (Figs. 4 & 5).

C. jekeli is peculiar in exhibiting anatomical effects of anticlockwise 'retournement' quite frequently. Tracheal supply for the aedeagus was examined in twenty males of this species. Out of these eleven showed effects of clockwise and nine of anticlockwise 'retournement' (Fig. 6). In several instances an individual with an aedeagal tracheal supply suggesting anticlockwise 'retournement' was also examined from the standpoint of nervous supply for the aedeagus and aedeagal muscles, which supported the above pointed inference regardng the direction of 'retournement'.

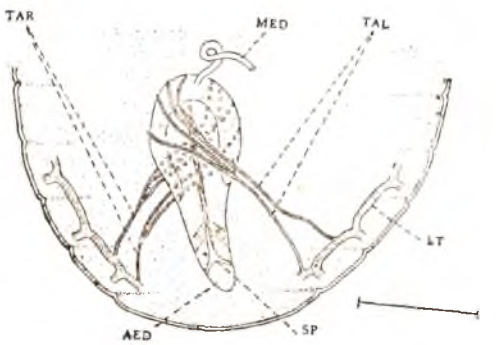


Fig. 6. *C. jekeli*, showing the tracheal supply for the aedeagus, indicating anticlockwise 'retournement'.

DISCUSSION

In this context only a small number of bruchid species could be examined. But, as 'retournement' of the aedeagus has been found indicated invariably in all the species studied, it may be inferred that 'retournement' of the aedeagus is prevalent and possibly universal in Bruchidae. As far as the authors are aware the present communication is the first record of this phenomenon in this family.

The phenomenon of 'retournement' in Bruchidae has been found quite comparable to that in Chrysomelidae. As in Chrysomelidae, in most Bruchidae it is in the clockwise direction, when seen from behind, and is through about 180°. In Bruchidae, as also in Chrysomelidae (KUMAR & VERMA, 1971), the 'retournement' is independent of terminal abdominal segments; in none of the bruchid species examined there is any asymmetry of the terminal abdominal segments and in all, the anus is situated dorsal to the opening of the genital pocket within the anogenital vestibule. The 'retournement' of the aedeagus in Bruchidae is yet another point of resemblance with Chrysomelidae.

Among the species examined *C. jekeli* is peculiar in showing clockwise as well as anticlockwise 'retournement'. As has been noted above, out of twenty males of this species examined for aedeagal tracheae, in eleven the 'retournement' indicated was clockwise and in nine anticlockwise. Thus the 'retournement' in this species seems to be clockwise and anticlockwise equally readily.

ABBREVIATIONS USED IN FIGURES

AED–aedeagus; GA–terminal abdominal ganglion, compound; LT–lateral longitudinal tracheal trunk; MED–median ejaculatory duct; NA–right and left aedeagal nerves fused basally; NAL–left aedeagal nerve; NAR–right aedeagal nerve; SP–spiculum; TAL–left aedeagal trachea/tracheae; TANL–left nerve/nerves for the terminal part of the abdomen; TANR–right nerve/nerves for the terminal part of the abdomen; TAR–right aedeagal trachea/tracheae.

Torsion of the male terminalia in Diptera is always clockwise (VAN EMDEN, 1953). As has been pointed out by VERMA (1969) in all those Coleoptera, in which the 'retournement' of aedeagus has been described and its direction has been mentioned, the direction is clockwise, when seen from behind. In some cassidine Chrysomelidae anticlockwise 'retournement' may be found exceptionally (VERMA & KUMAR, 1972). Anticlockwise 'retournement' is indicated also in the work of EVANS (1960-61) on the Cryptophagid, *Atomaria,* which has a phytophagoid aedeagus.

Acknowledgement:- The authors are indebted to Shri N. C. VERMA, Principal, J. H. Government College, Betul, for facilities to work and to the Commonwealth Institute of Entomology, London, for identification of material.

REFERENCES

CROWSON, R. A. (1960) The phylogeny of Coleoptera. *A. Rev. Ent.*, **5**: 111–134.

EVANS, M. E. G. (1960–61) The muscular and reproductive systems of *Atomaria ruficornis* MARSHAM (Coleoptera, Cryptophagidae). *Trans. R. Soc. Edinb.*, **64** : 297–399.

JEANNEL, R. (1955) *L' Edeage*. Museum National d'Histoire Naturelle, Paris.

KINGSOLVER, J. M. (1970) A study of the male genitalia in Bruchidae (Coleoptera). *Proc. ent. Soc. Wash.*, **72** : 370–386.

KUMAR, D. & K. K. VERMA (1971) 'Retournement' of the aedeagus in Chrysomelidae (Coleoptera, Phytophaga). *J. nat. Hist.*, **5** : 635–642.

VAN EMDEN, F. I. (1953) The male genitalia of Diptera and their taxonomic value. *Trans. IX Intl. Congr. Ent.*, **2** : 22–26.

VERMA, K. K. (1969) Functional and developmental anatomy of the reproductive organs in the male of *Galerucella birmanica* JAC. (Coleoptera, Phytophaga, Chrysomelidae). *Annls. Sci. nat. Zool.* Ser. 12, **11**: 139–234.

VERMA, K. K. & D. KUMAR (1972) The aedeagus, its musculature, and 'retournement' in *Aspidomorpha miliaris* F. (Coleoptera, Phytophaga, Chrysomelidae). *J. nat. Hist.*, **6** : 699–719.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 175 *to* 180

THE DEVELOPMENTAL ANATOMY OF THE NERVOUS SYSTEM OF *ASCHISTONYX CRATAEVAE* (MANI) (DIPTERA : CECIDOMYIIDAE)[1,2]

USHA SHARMA
School of Entomology, St. John's College, Agra, India 282002

(*Received 20 November 1976*)

The paper deals with the developmental anatomy of the nervous system in the gall midge, *Aschistonyx crataevae*. The nervous system in the larval instars consists of a brain and a chain of ten ganglia. During metamorphosis it differentiates into three distinct masses, cephalic, thoracic and abdominal. The developmental changes consist mainly of differentiation and consolidation.

INTRODUCTION

Aschistonyx crataevae (MANI), is a midge forming galls on the flower buds of *Crataeva religiosa* FORST., a common flowering tree, which blooms profusely during the months of April and May. A description of the nervous system in the larval instars and the changes it undergoes during pupation is given in this paper. The changes are described under three heads : early (35 hr) middle (72 hr) and late pupal (135 hr) stages. The pupal duration is approximately 136 hrs at 35–38°C and 36–39% RH.

The nervous system of cecidomyiid larvae has been studied in *Cecidomyia resinicoloides* (WILLIAMS, 1910), *Rhabdophaga saliciperda* (SEN, 1938) *Dasyneura leguminicola* (METCALFE, 1933), *Oligotrophus oleariae* (ANDERSON, 1935) and *Amradiplosis allahabadensis* (SUMAN DEVI, 1971). These authors have described the nervous system in the last instar larvae only and little is known about the developmental changes in the nervous system during pupation.

[1] Contribution No. 234 from the School of Entomology, St. John's College, Agra.

[2] Part of work approved for the degree of Ph. D. in the University of Agra.

MATERIALS AND METHODS

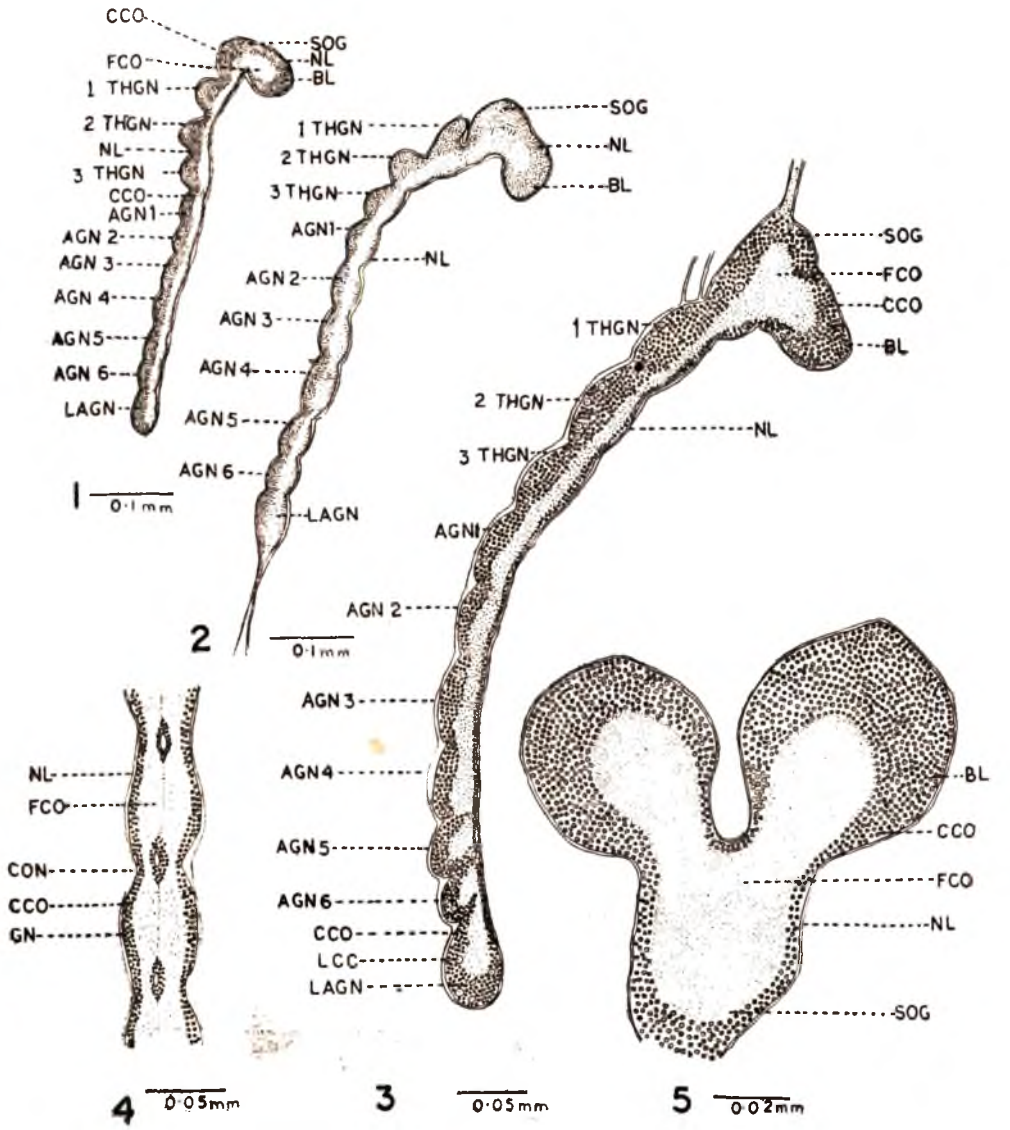
The flower galls of *Crataeva religiosa* FORST were opened carefully, to collect the larval instars. For pupation pinky orange last instar larvae were placed in moist sand. The larvae were fixed in hot alcoholic Bouin's fluid at 40° C for 18–24 hrs. The pupal stages were also fixed in hot alcoholic Bouin's, but were placed, according to their age, in separate numbered glass vials. The material was processed in the usual manner for microtomy but tertiary butyl alcohol and amyl acetate were used in place of absolute alcohol and xylene and sections were cut at 8–10μ in transverse and sagittal planes. The sections were stained with Mallory's triple stain.

RESULTS AND DISCUSSION

Larval Instars

The central nervous system in the second, third and fourth instar larvae consists of a brain and ventral nerve cord (Figs. 1–3). It lies immediately ventral to the alimentary canal and closely associated with it lie the ventral fat lobes. It resembles that of the other cecidomyiids such as in *Cecidomyia resinicoloides* (WILLIAMS, 1910), in *Rhabdophaga saliciperda* (SEN, 1938) in *Dasyneura leguminicola* (METCALFE, 1933) and in *Oligotrophus oleariae* (ANDERSON, 1935)

Brain:– The brain in the second, third and fourth instar larvae is represented by



Figs. 1–3. Sagittal sections of the central nervous system of second, third, and fourth instar respectively of *Aschistonyx crataevae*. Fig. 4. H. S. Passing through a portion of ventral nerve cord of fourth instar. Fig. 5. T. S. passing through the brain of fourth instar.

AGN 1–6–First to sixth abdominal ganglia; BL–Brain lobe; CCO–Cellular cortex; CON–Connective; FCO–Fibrous core; GN–Ganglion; LAGN–Last abdominal ganglion; NL–Neurilemma; SOG–Suboesophageal ganglion; 1–3 THGN–First to third thoracic ganglia.

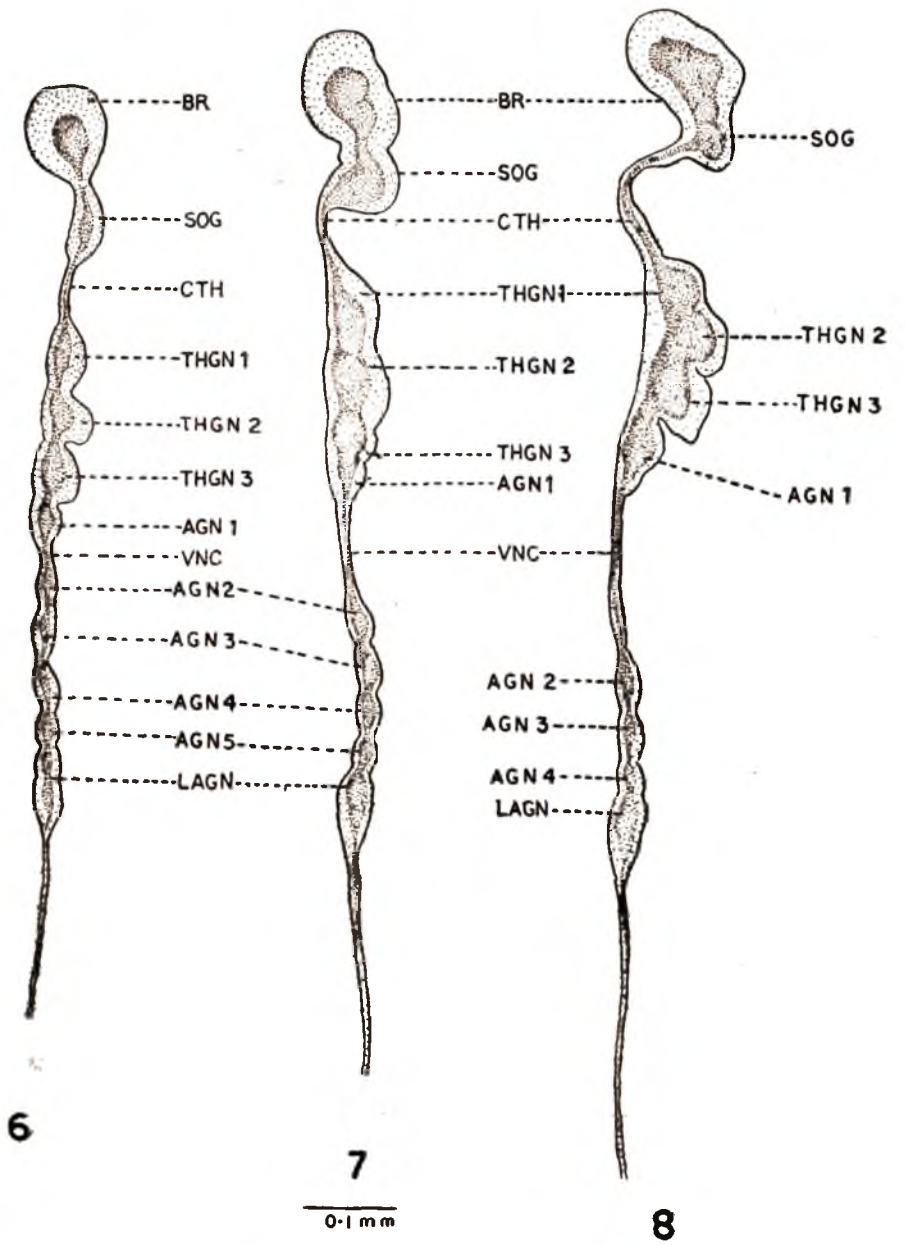
a pair of supraoesophageal ganglia or cerebral lobes and a suboesophageal ganglion (Figs. 1–5). Though similar in structure it exhibits a progressive increase in size corresponding to the growth of the larva. The cerebral lobes are fused to each other ventrally, but are not connected by any nervous strand dorsally (Fig. 5). IPE (1971) makes similar observation in *Melanagromyza obtusa,* but in *Dasyneura leguminicola* METCALFE (1933) reports the presence of a nervous collar around the oesophagus and in *Amradiplosis allahabadensis* there is a thick protocerebral commissure (SUMAN DEVI, 1971). The larval brain (Figs. 1, 2, 3 & 5) is composed of a fibrous core, surrounded by a cellular cortical layer which is ensheathed by the neurilemma. The medullary regions of the cerebral lobes and suboesophageal ganglion are contiguous and are seen as a compact mass with no specialised regions distinguishable even in the last instar larva (Fig. 5). This is comparable to the condition in *Cecidomyia resinicoloides* (WILLIAMS, 1910), *Dasyneura leguminicola* (METCALFE, 1933) and *Rhabdophaga saliciperda* (SEN, 1938). But in *Amradiplosis allahabadensis* the supraoesophageal ganglion consists of protocerebral lobes, central body, corpora pedunculata and optic lobes (SUMAN DEVI, 1971). The cortex is composed of numerous closely packed small cells which stain deeply, have well defined cell walls and conspicuous nuclei.

Ventral nerve cord:-- The ventral nerve cord in the second, third and fourth instar larvae (Figs. 1, 2 & 3) is dorsally concave and is composed of a chain of ten well defined ganglia, besides the suboesophageal ganglion. The first three ganglia of the chain are thoracic whereas the remaining seven are abdominal. SEN (1938) reports the presence of a single fused thoracic ganglionic mass in *Rhabdophaga saliciperda.* The thoracic ganglia are smaller than the suboesophageal ganglion but larger than the rest except the last abdominal ganglion. In all instars the ganglionic boundaries are distinct, interganglionic connectives are short and a pair of nerves arising from each ganglion are clearly visible.

The number of ganglia in the ventral nerve cord of cecidomyiid larvae is variable. In *Aschistonyx crataevae* there are ten ganglia, exclusive of the suboesophageal ganglion. However, there are fourteen in *Maiaster metroloas* (KIEFFER, 1900), eight in *Dasyneura leguminicola* (METCALFE, 1933), ten in *Oligotrophus oleariae* (ANDERSON, 1935), nine in *Rhabdophaga saliciperda* (SEN, 1938) and *Amradiplosis allahabadensis* (SUMAN DEVI, 1971).

The nerve chain is composed of an inner fibrous medullary core (Figs. 1, 2, 3) and an outer cellular, cortical layer which is ensheathed by neurilemma. The histological details become progressively clearer as development porceeds further. In the last instar, besides the small, compactly arranged cortical cells a few large cells are distinguishable in the cortical region. In the second to fourth instars the thickness of the cortical layer is not uniform. The nerve cord exhibits a thicker cortical region ventrally and a nearly uniform thickness dorsally. The fibrous cores of the ganglia are incompletely fused (Fig. 4).

The central nervous system of the larval instars of *Aschistonyx crataevae,* like other cecidomyiid larvae is not as consolidated as the central nervous system of various cyclorrhaphous larvae. BONDENSTEIN (1950) in *Drosophila melanogaster* and IPE (1971) in *Melanagromyza obtusa* describe a nervous system composed of a brain and a compound ventral ganglion. IPE (1971) distinguishes the segmental boundaries of three thoracic and eight abdominal ganglia in the fused



Figs. 6–8. Sagittal sections of the central nervous system of early, mid and late pupal stages.

AGN 1–5—First to fifth abdominal ganglia; BR–Brain; CTH–Cephalothoracic cord; LAGN–Last abdominal ganglion; SOG–Suboesophageal ganglion; THGN 1–3—First to third thoracic ganglia; VNC—Central nerve cord.

ventral ganglion of *M. obtusa*. The compound ventral ganglion of cyclorrhaphous larvae is represented by the suboesophageal, three thoracic and seven abdominal ganglia of the ventral nerve cord in the larval instars of *Aschistonyx crataevae*.

Pupal Stage

During pupal development the medullary masses of the larval brain differentiate and give rise to characteristic adult structures, whereas the ten ganglia of the nerve cord consolidate to form the three thoracic and four abdominal ganglia interconnected by the cephalothoracic and ventral nerve cords of the adult.

The nervous system in the pupal stage is composed of three distinct ganglionic masses, the cephalic, thoracic and abdominal. The head, thorax and abdomen are distinct even in the early pupal stage, and owing to eversion of the head, the central nervous system undergoes a topographical change.

Cephalic mass:– In the early pupal stage the brain (Fig. 6) undergoes a flexure and comes to lie in line with suboesophageal ganglion and the nerve cord. The medullary region of the cephalic ganglionic mass which consists of the brain lobes and suboesophageal ganglion, show an increase in size. The cerebral lobes have completely fused dorsally and thus the oesophagus becomes encircled by nervous tissue. The suboesophageal ganglion which was broadly attached to the first thoracic ganglion in the last instar larva is now connected to it by a thin cephalothoracic cord.

As development proceeds there are certain marked topographical changes in the brain, it flexes itself and the flexion is increasingly marked in the midpupal stage. The suboesophageal ganglion is now connected to the thoracic mass by a prominent slightly curved cephalo-throracic cord (Fig. 7). The medullary region of the brain shows a further increase in size and differentiates itself into nerve centers.

Further development involves differentiation of the brain and by the late pupal stage (Fig. 8) the brain is topographically complete and shows greater resemblance to that of the adult. The various medullary nerve centres characteristic of the adult brain are easily recognisable and the cortical layer is considerably reduced in thickness. A very conspicuous long and prominently curved cephalothoracic cord (Fig. 8) connects the cephalic to the thoracic mass in the late pupal stage.

Thoracic mass:– In the early pupal stage (Fig. 6) the thoracic mass of the nervous system consists of three distinct thoracic ganglia. Closely associated with the third thoracic ganglion is seen the first abdominal ganglion. In the midpupal stage (Fig. 7) the thoracic mass consists of three closely approximated ganglia. The third thoracic ganglion, the fusion product of the third thoracic and the first abdominal ganglia, is connected by a prominent nerve cord with the second abdominal ganglion. In the late pupal stage (Fig. 8), the thoracic mass still consists of three ganglia, but the first two ganglia are smaller than the third. The last thoracic ganglion incorporates the first abdominal one and is connected by a fairly long ventral nerve cord to the second abdominal ganglion.

Abdominal mass:– In the early pupal stage (Fig. 6) five ganglia are visible in the abdominal region. The first abdominal ganglion is closely approximated to the third thoracic, and the penultimate to the last abdominal. The elongated last abdominal ganglion, marked externally by a slight constriction is the largest and sends a thick

nerve which extends till the terminal abdominal segments. In the midpupal stage (Fig. 7) the number of ganglia in the abdomen remains five, but they are more closely approximated. As development proceeds the nervous system is marked by further consolidation of ganglia in the abdominal region, becomes topographically complete and shows great resemblance to that of the adult. In the late pupal stage (Fig. 8) there are only four abdominal ganglia. The second, third and fourth are distinct whereas the fifth has apparently fused with last abdominal ganglion. The last abdominal ganglion of the late pupa is a composite ganglion formed of the fusion of the fifth, sixth and seventh abdominal ganglia of the last instar larva. It is much longer than the other abdominal ganglia and tapers posteriorly to give rise to a thick nerve which runs posteriorly till the last abdominal segment.

Detailed investigations on the postembryonic development of the nervous system in Diptera have been carried out by HERTWECK (1931), SATIJA & AGARWAL (1966) in *Drosophila melanogaster*. Metamorphosis of the nervous system of *Aschistonyx crataevae* proceeds in a manner similar to that described by IPE (1971) in *M. obtusa* with differences in rate and scale of consolidation. The larval nervous system of *M. obtusa* is more concentrated than the pupal and its consolidated larval ventral ganglion differentiates into the pupal thoracic and abdominal nerve masses and the connective cords. In *Aschistonyx crataevae*, the changes from the larval to the pupal are those of consolidation, there being ten distinct ganglia in the chain excluding the anteriormost suboesophageal in the larva, giving rise to three thoracic and four abdominal ganglia of the adult. The dorsal flexure of the brain reported by SATIJA & AGARWAL (1966) in *D. melanogaster* and by IPE (1971) in *M. obtusa* has also been observed in *Aschistonyx crataevae*.

REFERENCES

ANDERSON, J. A. T. (1935) The morphology and anatomy of the immature and adult stages of *Oligotrophus oleariae* MASK. (Cecidomyiidae: Diptera). *Proc. zool. Soc. Lond.*, 405–420.

BODENSTEIN, D. (1950) The postembryonic development of *Drosophila melanogaster*, 275–367, *in*: *Biology of Drosophila* (ed. DEMEREC), J. Wiley & Sons, New York.

HERTWECK, H. (1931) Anatomie und variabilität des Nervensystems und der Sinnesorgane von *Drosophila melanogaster* (MEIGEN). *Z. wiss. Zool.*, **139** : 559–663.

IPE, A. S. (1971) Studies on the postembryonic development of *Melanagromyza obtusa* (MALLOCH), a pest of *Cajanus indicus* L. (Hindi : Arhar) (Agromyzidae : Diptera). Agra University Ph.D. Thesis (Unpublished).

KIEFFER, J. J. (1900) Monographie des Cecidomyidae d'Europe et d' Algeric. *Annls. Soc. ent. Fr.*, **69** : 181–472.

METCALFE, M. E. (1933) The morphology and anatomy of the larva of *Dasyneura leguminicola* LINN. (Diptera). *Proc. zool. Soc. Lond.*, **1** : 119–130.

SATIJA, R. C. & VEENA AGARWAL (1966) Morphological development and growth of the brain of *Drosophila melanogaster*. *Res. Bull. Panjab Univ. Sci.*, **17** (1–2) : 27–34.

SEN, P. (1938) On the structures (Anatomical and Histological) of the full grown larva of *Rhabdophaga saliciperda* DUFOUR (Cecidomyiidae : Diptera). *Zool. Jb.* (*Anat.*), **65** : 37–62.

SUMAN DEVI (1971) Morphology and Biology of an economically important gall midge with special reference to the study of gall formation. D. Phil. Thesis, University of Allahabad.

WILLIAMS, F. X. (1910) The anatomy of the larva of *Cecidomyia resinicoloides* WILLIAMS. *Ann. ent. Soc. Am.*, **3** : 45–57.

Entomon, 1977, *Vol.* 2. *No.* 2, *pp* 181 *to* 187

HEAD AND ITS APPENDAGES OF *BRACHYMERIA* WESTWOOD (HYMENOPTERA : CHALCIDIDAE)

T. C. NARENDRAN, P. J. JOY[1] & K. J. JOSEPH
Department of Zoology, University of Calicut, Calicut, India 673635

(*Received* 27 *April* 1977)

The cuticular structures of the head of *Brachymeria* are described. The sclerites of the head capsule are fused and many of the usual sutures are not distinguishable. Although the anetenna of *Brachymeria* is composed of thirteen segments, only eleven segments are distinguishable since the last three are fused to form a club. The mouth parts are of the licking type. The tentorium is very much modified from the generalised insectan type.

INTRODUCTION

Though the general morphology of the parasitic Hymenoptera is somewhat well known, not much work has been done on the morphology of the members of the Chalcididae. While BOUCEK (1951), BURKS (1938, 1960), HABU (1960), MASI (1950), NIKOLSKAYA (1952) and RUSHKA (1922) restricted their studies to taxonomic descriptions, HANNA (1935) and others studied their morphology to a certain extent. As no detailed morphological studies have been carried out on the genus *Brachymeria*, the present study has been undertaken.

MATERIALS AND METHODS

The species *Brachymeria lasus* (WALKER) has been dealt with in deatail and a comparison has been made with certain other species of the genus. For studying the external cuticular structures, the head was removed and observed under Leitz Wetzlar Ortholux and Bausch & Lomb Stereo Zoom microscopes. Later the head was treated with 10% KOH to remove the muscles and to make observations of the internal as well as external parts. The mouthparts and tentorium were dissected out and treated with 10% KOH. The diagrams were drawn by using camera lucida

OBSERVATIONS

Brachymeria (*Brachymeria*) *lasus* (WALKER)

The head is large and is about $1\frac{1}{4}$ as wide as its length. It is somewhat oval when viewed from front (Fig. 1). It is closely punctured and pubescent. The punctures are usually rough, reticulated and interspaces between them are somewhat carinate in part. The head is hypognathous and roughly oval in profile (Fig. 2). The compound eyes are large and conspicuous with many hundreds of minute facets. A distinct line representing the ocular sulcus is present around each compound eye. The ocelli are three in number and are disposed in a triangle on the vertex.

The walls of the head capsule are fused and many of the usual sutures are absent. However, the sclerites of the head can be distinguished topographically from the position of the parts in relation

[1] Present address: Horticultural College, Kerala Agricultural University, Mannuthy, Kerala, India 680651.

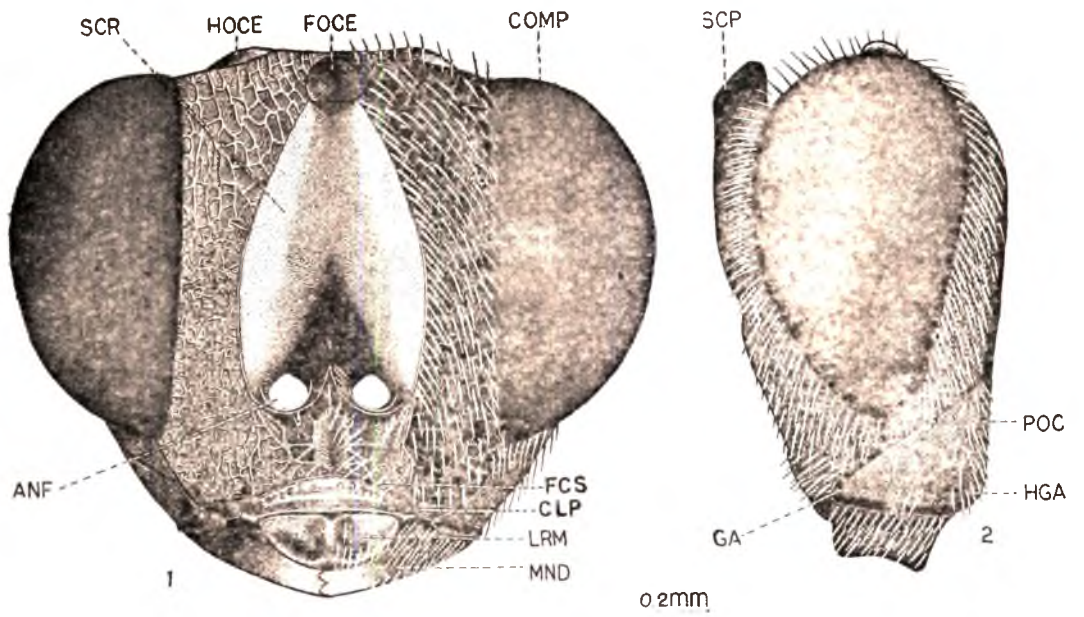


Fig. 1. Head, front view (pubescence removed from one side). Fig. 2. Head in profile.

to fixed characters of the head in the generalised type. The frons is generally without preorbital carinae. Scrobe is a smooth and shiny depression into which the scapes of the antennae fit during repose. The scrobe reaches the front ocellus and is distinctly marked off carinaceously. The lateral ridges of the scrobe are produced in front of the antennal sockets. Area below scrobe has a smooth median raised portion. The median ocellus is a little larger than th lateral ocellus.

The Clypeus is a transverse sclerite, distinctly raised and delimited by a carinate fronto-clypeal sulcus. The clypeal region consists of an anteclypeus and a postclypeus. The postclypeus is shiny and provided with punctures. The anteclypeus is without punctures. The anterior tentorial pits are not very distinct as they are mingled with the pits on the frons but on careful observation it can be made out on or adjoining the frontoclypeal suclcus on either side. The posterior surface of the head (Fig. 3) is occupied by the occipital foramen situated in the median line slightly dorsal than ventral. There is a membranous neck. The occiput is the undefined area lying dorsally and a little dorso-laterally to the occipital foramen. The area below and behind the compound eyes are the genae. The genae are divided by a keel or ridge into a pregenal region and a postgenal region which is smooth. The fronto-genal sulcus is strongly carinate; from this an oblique postorbital carina runs posteriorly and reaches the genotemporal margin (Fig. 2). Ventrally the occipital foramen is completed by the gular region (Fig. 3) which is constricted and narrowed and separated from the postgenae by two faint lateral lines which probably represent the ventral tips of postoccipital sulcus. The posterior tentorial pits are very faint and almost indistinguishable.

The antennae are inserted close together in front of the head between the eyes at the base of the scrobe and are separated by

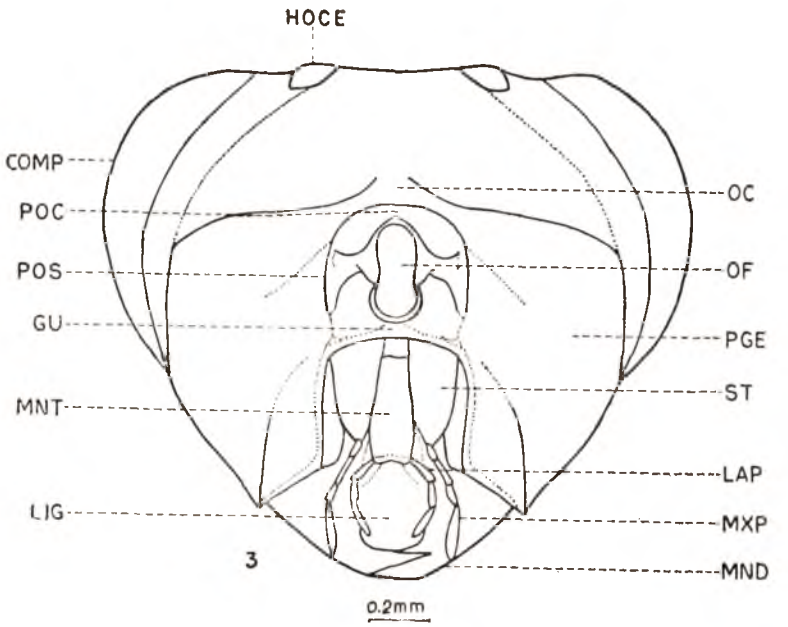


Fig. 3. Head, back view.

a moderately long inter-antennal projection (Fig. 4). When the antennae are removed it is possible to see the antafossa (Fig. 1) which is margined by the antennal sclerites (Fig. 4) circumscribed by the antennal sulci. Although the antennae are originally composed of thirteen segments, only eleven segments are clearly distinguishable since the last three segments have fused into a club (Figs. 5 & 6). The apical segment of the club is often invisible and sutures between the original three segments are rarely distinct except a faint anterior margin of the basal segment of the club (Fig. 10). The first segment of the antenna, the scape (Figs. 5 & 6), is articulated to the antafossa by a slender segment called radicula (Figs. 5 & 6). The radicula is immovably connected with the scape. The scope is longer than the combined lengths of the segments 4 to 6 and does

ABBREVIATIONS USED

ANF–antafossa; AHRS–long setae; ANTSC–antennal sclerite; ARM–long arm of tentorium; CAN–canal; CD–cardo; CLB–club; CLP–clypeus; COMP–compound eyes; CRD–chitinous rod; CR–chitinous rim; FCS–fronto-clypeal sulcus; FOCE–front ocellus; GA–front genal angle; GAL–galea; GU–gular region; HGA–hind genal angle; HOCE–hind ocellus; INCCH–incomplete circular chitinous pieces; INT–inter-antennal projection; INW–inflexed walls; LAC–lacinia; LAP–labial palp; LIG–ligula; LMND–left mandible; LMR–lower margin of occipital foramen; LR–labrum; MBF–membranous flap; MC–median carina; MND–mandible; MNT–mentum; MXP–maxillary palp; 1MR–brush like membrane; 2MR–thin membrane; OC–occiput; OF–occipital foramen; PED–pedicel; PGE–postgena; POC–post orbital carina; POS–post-occipital sulcus; RAD–radicula; RIG–ring segment; RMND–right mandible; SCP–scape; SCR–scrobe; SENB–basiconic sensillae; SENP–placoid sensillae; SENPC–round sensillae; ST–stipes; TGP–tongue-like process; TKB–thickened portion; UPMR–upper margin of occipital foramen.

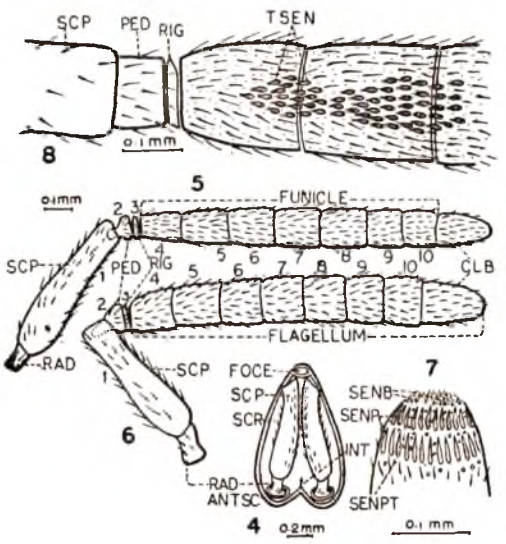


Fig. 4. Scrobe showing insertion of the scape; Fig. 5. Antenna of female; Fig. 6. Antenna of male; Fig. 7. Apex of club; Fig. 8. Ventral view of the basal funicular segments of the male, showing the trichoid snsillae.

not project beyond the front ocellus. The basal part of the scape is broader than its distal part. The rest of the antenna is connected with the scape by a joint allowing a movement of 180° in the verticl front-to-back plane. The pedicel (Figs. 5 & 6) or the second segment of the antenna mediates the jointed connection with the scape. The pedicel is followed by the ring segment which is followed by the flagellum consisting of 7 segments forming the funicle and a club formed of 3 fused segments. The flagellar segments in the males are stouter than those in the female. The measurements of the segments are as in figures 5 & 6. The segments are connected to one another by their walls inflexed interna'ly as shown in Figs. 9 & 10.

The sense organs on the funicular and club segments of the antennae consist of narrow plate organs or placoid sensillae (Fig. 7) interspersed with small round sensillae (Fig. 7). In addition to these, the antennal segments are covered with sensory hairs which are relatively more numerous in the males than in the females. The club also bears numerous delicate thin-walled setae and a few basiconic sensillae. These basiconic sensillae are small peg-like structures with rounded tips. The trichoid sensory setae (Fig. 8) are present on the ventral side of the segments four to eight in the male.

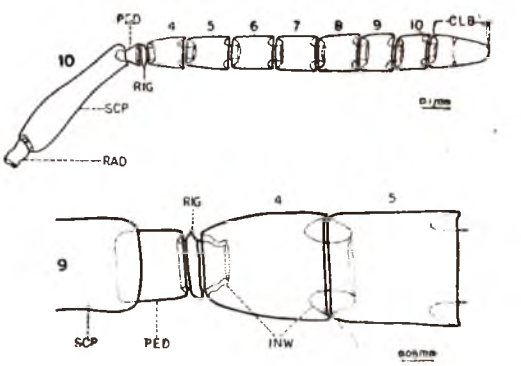


Fig. 9. Enlarged view of antenna (in part) showing intersegmental connections; Fig. 10. Whole antenna showing intersegmental connections.

The mouth parts are of the licking type. The labrum (Fig. 11) is movably attached at its base to the lower margin of the clypeus between the two mandibles. Its free edges bear long setae. There are tube-like structures running inside the labrum (not represented in the figure) ending at the base of each seta; these seem to indicate the course of the nerves innervating the hairs. The labrum has a median elevated ridge or carina. The epipharynx bears small setae and a tongue-like process as in figure 12. The mandibles (Fig. 13) are solid compact pieces of chitin bearing setae on their outer side. Each mandible is articulated to the head by a ginglymus and a condyle.

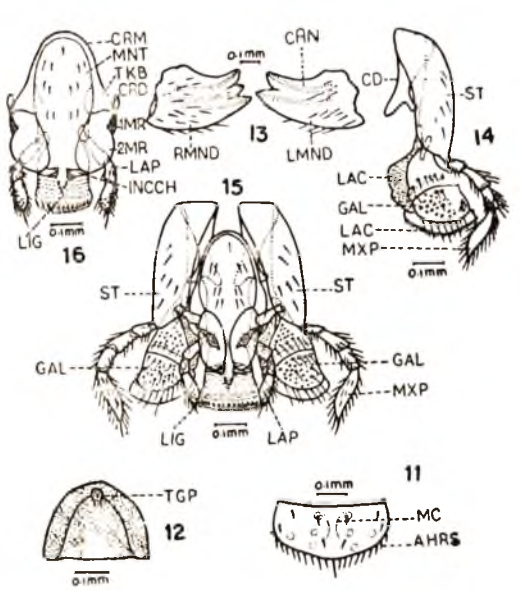


Fig. 11. Labrum (viewed from the front); Fig. 12. Epipharynx; Fig. 13. Outer view of mandibles; Fig. 14. Maxilla; Fig. 15. Labio-maxillary complex (slightly stretched); Fig. 16. Labium (pressed dorsoventrally).

The ginglymus articulates with a convex process of the clypeus and the condyle fits into a socket on the ventral end of the gena. The mandibles are more or less convex on the outer side, concave on the innerside and conceal the other mouthparts from the front. The right mandible is tridentate and the left one is bidentate. Internally, a canal enters each tooth of the mandible; these canals originate in the basal half of each mandible and become narrowed towards the teeth of the mandibles. The movement of the mandibles is brought about by the abductor and adductor muscles. The maxillae (Fig. 14) and the labium are closely connected to form a complete structure suspended from the postgenal margins of the cranium by the basal articulations of the maxillary cardines. Proximally each cardo articulates with the internal wall of the cranium and distally it is broader and articulates with the base of the stipes. The stipes is closely pressed to the mentum along its inner aspect (Fig. 15). At its distal end it bears an outer galea and an inner lacinia. The galea and lacinia are closely applied and incompletely separated from each other. The outer surface of the galea is beset with very fine articulated setae. The lacinia is a lamellate lob closely applied to the galea on its inner aspect. Both galea and lacinia are connected to the distal end of stipes by very small chitinised rods and membranes. The lacinia has small minute setae at its basal half and at the outer margin of the distal half. Each maxillary palp is articulated on a slight protuberance and fits into a socket by its basal segment. Each palp consists of four segments, the basal segment is the smallest and the distal one the longest. Each segment carries a number of setae which are more numerous on the distal segment. In addition to those setae there is a longer some what prominent seta at the tip of the distal segment. The labium (Fig. 16) is situated between the maxillary stipites to which it is attached by a membrane and by a chitinous rod on each side. The mentum is a narrow chitinised part between the stipites and stretches from the gula to the extremity of the labrum. Its outer borders are strengthened by a more chitinised rim which towards the two laterodistal region become thickened as shown in Fig. 16. Each of these thickened parts is articulated to another peculiar specialised structure which is provided with a chitinous rod and a membrane provided with long fine brush-like setae. The glossae and paraglossae have become united to form a single plate, the ligula. It is situated at the distal end of the mentum. It consists of a circular piece of chitin laterally compressed and incomplete on the ventral side. A very thin membrane with the surface covered with very minute setae is stretched on each side of the mentum. The labial

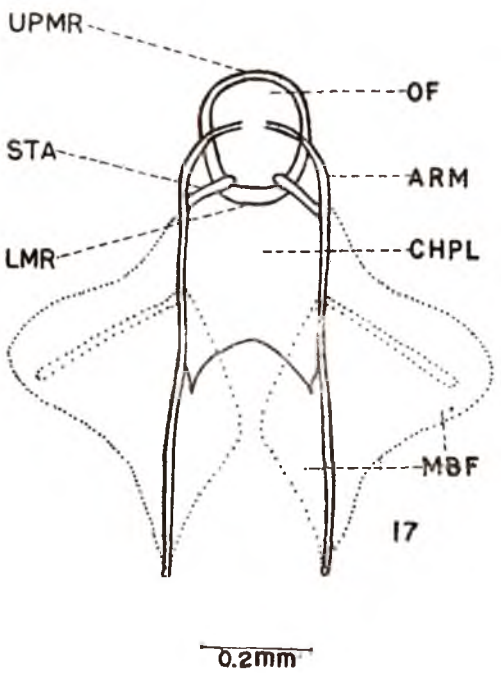


Fig. 17. Tentorium.

palps are articulated in deep sockets on the ventral anterior surface of the mentum. Each labial palp is three segmented. The proximal segment is a little shorter than the distal one and the middle one is the shortest. Each segment carries scattered articulated setae, but those on the distal segment are more numerous with a prominent one at the tip.

The tentorium (Fig. 17) is greatly modified from the generalised insectan types. The long arms are connected on either side of the upper margin of the clypeus; these then proceed backwards and upwards and finally reach the occipital foramen. After reaching the foramen the arms curve to the inner side of the foramen and divide it into an upper and a lower half. There is also another pair of short arms arising from the long arms. These short arms proceed obliquely towards the occipital foramen and fuse with the thick and rigid lower margin of the occipital foramen. Between the upper part of the two long arms there is a heavily chitinised plate. Two membranous expansions are present on either side of the two main tentorial arms. The inner membranous expansions are smaller than the outer ones.

Structure of the head and mouth parts in other species of Brachymeria

Apart from the species *B.* (*B.*) *lasus* (WALKER), the head of several other species of *Brachymeria* have been examined. The heads of all these species have the same fundamental characterstics as *B.* (*B.*) *lasus* except some subgeneric and species differences mentioned by JOSEPH *et al.* (1973), BURKS (1960) and HABU (1960). The head of the subgenus *Matsumurameria* differs mainly from the head of the subgenus *Brachymeria* in having the clypeus fused with the frons. Subgenus *Pseudobrachymeria* has the vertex with a transverse carina extending across just posterior to anterior ocellus and this carina extends downward on either side of frons or parascrobal space. Subgenus *Gahanula* has also got the fronto-vertex carinate but with vague or faint carinae. The mouth parts and tentorium of the species *B.* (*M.*) *criculae*, *B.* (P.) *psyche* and *B.* (*G.*) *discreta* could not be adequately examined due to want of suitable material for study.

DISCUSSION

In the genus *Brachymeria* (and in the subfamily Brachymeriinae) the antennae are inserted at or dorsal to the level of ventral margins of compound eyes whereas in the related subfamily Haltichellinae the antennae are inserted always below the level of ventral margins of the compound eyes. In Dirhinae and Epitraninae also the antennae are attached below the level of the

ventral margins of the compound eyes. In Chalcidinae the antennal sockets are situated usually in the centre of frons. The head of Brachymeriinae has no horns as in the case of the Dirhininae.

The antenna consists of thirteen segments of which the apical three form the club in all members of the family Chalcididae. The three segments of the club, the eleventh, twelfth and thirteenth are distinct in species of some genera such as *Spilochalcis* and *Chalcis*, but in most species they become more or less indistinct, sometimes completely fusing into one segment (HABU, 1961). In *B. lasus* and in most other species of *Brachymeria* the apical segment of the club is often invisible and the sutures between the original three segments are rarely very distinct. In the case of *Euchalcidia caryobori* the canals found inside of the teeth of the mandible are referred to as chitinous pillars by HANNA (1935). Recent information suggests that these canals are the canals of the mandibular glands.

The transverse carina of vertex extending downwards on either side of frons in *Pseudobrachymeria* and *Gahanula* are found well represented in *Antrocephalus* and *Eucepsis*.

HANNA (1961) noted that in *Euchalcidia carybori* the peculiar rod-like structure and membrane articulated to the thickened knob of the outer border of mentum on each side, may be paraglossa or lacinia or a specialisation. According to the same author if this structure is considered as the lacinia, then the membrane which is closely attached to the galea and which is considered as lacinia would be simply a lining of the galea. From the nature of the structure and articulation it seems that the peculiar rod-like structure and membrane are a specialisation and not lacinia or paraglossa. In *Brachymeria* (and probably in other members of Chalcididae) the glossae and paraglossae have become united to form the ligula.

Acknowledgements:- This research was financed in part by a grant made by the United States Department of Agriculture under P. L. 480 (Grant No. FG-IN-327 & Project No. A7-ENT-59).

REFERENCES

BOUCEK, Z. (1951) The first revision of the European species of the family Chalcididae (Hymenoptera). *Acta entomologica Mus. Nat. Pragae*, **27** : Suppl. **1**: 1–18.

BURKS, B. D. (1938) A study of Chalcidoid wings (Hymenoptera). *Ann. ent. Soc. Am.*, **31**: 157–160.

BURKS, B. D. (1960) A revision of the genus *Brachymeria* WESTWOOD in America North of Mexico (Hymenoptera : Chalcididae). *Trans. Am. ent. Soc.*, **86** : 225–273.

HABU, A. (1960) A revision of the Chalcididae of Japan with descriptions of sixteen new species. *Bull nat. Inst. agr. Sci., Tokyo*, Ser. C., No. **11**: 131–365.

HABU, A. (1961) Chalcididae and Leucospidae from Shansi, North China (Hymenoptera), *Mushi*, **35** (11): 79–86.

HANNA, A. D. (1935) The morphology and anatomy of *Euchalcidia caryobori* H. *Bull. Soc. ent. Egypte*, **19** : 326–364.

JOSEPH, K. J., T. C. NARENDRAN & P. J. JOY (1973) *Oriental Brachymeria* (Hymenoptera : Chalcididae). Zoological Monograph No. 1, Department of Zoology, University of Calicut, India, 215 pp.

MASI, L. (1950) Materiali per una monografia delle *Brachymeria palearticha* (Hymen. Chalcidoidea). *Eos, Madr.*, Tom. extraord, 27–58.

NIKOLSKAYA, M. N. (1952) *The Chalcid Fauna of the U.S.S.R. Chalcidoidea*. Translated from Russian (1963) 593 pp. Published for the National Science Foundation, Washington, D. C. by the Israel Program for Scientific Translations, Jerusalem.

RUSHKA, F. (1922) Chalcididenstudien. III. Die europaischen Arten der Gattung *Chalcis* FABR. *Konowia*, **1** : 221–233.

Entomon, 1977, *Vol.* 2. *No.* 2, *pp.* 189 *to* 191

STUDIES ON THE GENITALIA OF MANGO STEM BORER, *BATOCERA RUFOMACULATA* DEGEAR (COLEOPTERA : CERAMBYCIDAE)

T. SURULIVELU & T. R. SUBRAMANIAM
Department of Entomology, Tamil Nadu Agricultural University, Coimbatore
India 641003

(Received 27 April 1977)

The structural details of male and female genitalia of *Batocera rufomaculata* DEGEER have been described with figures. This species differs from other cerambycids in having two ejaculatory ducts which empty separately into the internal sac. The absence of common ejaculatory duct is being reported for the first time in the genus *Batocera*.

INTRODUCTION

Mango stem borer, *Batocera rufomaculata* DEGEER (Cerambycidae : Coleoptera) is an important pest of mango in India. Earlier workers (STEBBING, 1907, 1914; BEESON & BHATIA, 1938; HUSSAIN & KHAN, 1940) have given a brief description about the external morphology of this beetle and information on the genitalia of this insect is lacking. Detailed description of the genitalia of the insect is presented in this paper.

MATERIALS AND METHODS

The beetles were relaxed by exposing to steam for 5 to 10 minutes and subsequently boiled in 10 per cent potassium hydroxide solution for 5 to 10 minutes, washed with distilled water, transferred to glacial acetic acid and again washed with distilled water. Then they were dehydrated in grades of alcohol and kept in either carbol chlorol or in alcohol so as to submerge (GOPALAN, 1962). The figures were drawn with the aid of a camera lucida. All the dissections were carried out under a 'Stereo-zoom' binocular microscope.

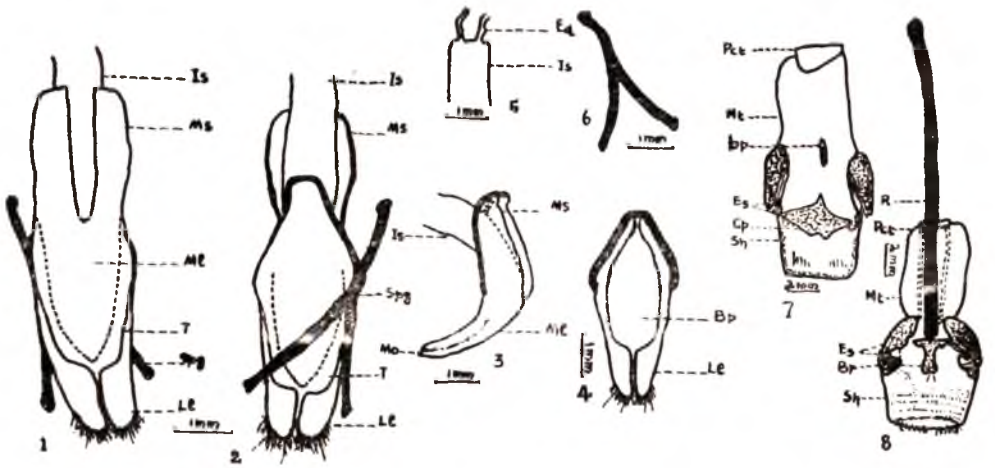
OBSERVATION

Male genitalia (Figs. 1 to 6)

The distinctive feature in the male genitalia is the absence of a common ejaculatory duct. The two ejaculatory ducts present empty themselves into the internal sac, which thins out and enters into the chitinised median lobe through the median foramen, terminating at the median orifice. The median lobe consists of a hollow curved cone of chitin which is slightly blunt at the apical end. At the basal end, its dorsal surface splits into two parts called median strut. For about one third of its apical end, the median lobe is split into a dorsal and ventral portion by a membrane running along either sides from the median orifice. Ensheathing the median lobe at its pointed end. is a circular ring of chitin called the tegmen. The tegmen shows a basal piece to which are attached two lateral lobes and a few stiff bristles are present on their apical parts. The spiculum gastrale is an inverted 'y' shaped piece of chitin and lies on the ventral side of the median lobe. The anterior arm of spiculum is bent towards the dorsal surface, while the two posterior arms are rounded at their ends with a tubercle towards the outer side near the apical end.

Female genitalia (Figs. 7 and 8)

The ovipositor is made up of a membranous tube, a chitinised hollow sheath and a



Figs. 1–6. Male genitalia of *Batocera rufomaculata*. 1. dorsal view; 2. ventral view; 3. median lobe; 4. tegmen; 5. internal sac with ejaculatory ducts; 6. spiculum gastrale. Figs. 7–8. Female genitalia of *B. rufomaculata*, dorsal and ventral views respectively. Bp–basal piece; bp–brown plate; Br–basal rod; Cp–chitinous plate; Ed–ejaculatory duct; Es–ears of sheath; Is–internal sac; Ll–lateral lobe; Ml–median lobe; Mo–Median orifice; Ms–median struct; Mt–membranous tube; Pct–partially chitinous tube; R–rod of ovipositor; Sh–sheath of ovipositor; Spg–spiculum gastrale and T–tegmen.

stout chitinised rod. The anterior end of the membranous tube is partially sclerotised. Medially, there is a rod-like, partially chitinised portion occupying the central part of the long membranous tube. The sheath portion of the ovipositor bears on each side anteriorly an ear or wing which is directed posteriorly. The membranous tube passes between these ears and the ears afford suitable surfaces for attachment of muscles, some of which may play a part in the working of ovipositor.

Borne by the anterior part of sheath ventrally and projecting into the abdomen almost as far as the metathorax is a stout chitinous rod. The rod is about three times the length of the sheath itself and shows grooves and ridges on its lateral surfaces. The posterior portion of the sheath is flattened dorso-ventrally and bears numerous bristles on its apical part. Distally the sheath bears a brownish chitinous plate which is pointed forwards and on either side groups of minute setae are seen. On either side of this chitinous plate, ears of sheath are seen and these are also chitinised.

DISCUSSION

The structural details of the male genitalia of *B. rufomaculata* correspond to other cerambycids in general, described by SHARP & MUIR (1912) and by RITCHIE (1921). Nevertheless, *B. rufomaculata* differs from the majority of cerambycids in having two ejaculatory ducts which empty themselves separately into the internal sac. The absence of the common ejaculatory duct is being reported for the first time in the genus *Batocera* and the morphological importance of this character needs further study. SHARP & MUIR (1912) also observed

the presence of two ejaculatory ducts in the cerambycid beetles belonging to the genus *Gnoma* and *Monochamus*.

Acknowledgement:- The senior author is thankful to the Indian Council of Agricultural Research for awarding a Research Fellowship and the Tamil Nadu Agricultural University for granting permission to publish these findings which formed part of M. Sc. (Ag.) thesis. The author is grateful to Dr. B. VASANTHARAJ DAVID for the help rendered by him in this study.

REFERENCES

BEESON, C. F. C. & B. M. BHATIA (1938) On the biology of the Cerambycidae, Coleoptera. *Ind. Forest Rec.*, **5** : 2-90.

GOPALAN, M (19c2) Studies on the morphology and bilogy of *Regmus importunites* DIST, (Miridae: Heteroptera). M. Sc. (Ag.) Dis. sertation submitted to Madras University, 65 pp.

HUSAIN, M. A. & A. W. KHAN (1940) Bionomics and control of the fig tree borer (*Batocera rufomaculata* DEGEER). *Indian J. agric. Sci.*, **10** : 945-960.

RITCHIE, W. (1921) The structure, bionomics and economic importance of *Saperda carcharias* LINN., 'The large popular Longhorn'. *Ann. appl. Biol.*, **7** : 299-343.

SHARP, D. & F. MUIR (1912) The comparative anatomy of the male genital tube in Coleoptera. *Trans. ent. Soc., Lond.*, 1912 : 477-642.

STEBBING, E. P. (1907) A note on the Duki fig tree borer of Baluchistan, *Batocera rubus* LINN. *Forest Bull.*, **10**: 1-7.

STEBBING, E. P. (1914) *Indian Forest Insects of Economic Importance. Coleoptera*. Eyre & Spottis woode Ltd., London, 648 pp.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 193 *to* 200

BIOLOGICAL STUDIES ON *EYPREPOCNEMIS ALACRIS ALACRIS* (SERVILLE) (ORTHOPTERA: ACRIDIDAE: GROWTH IN TERMS OF WEIGHT, LENGTH AND EYE-STRIPE NUMBER

M. C. MURALIRANGAN[1] & T. N. ANANTHAKRISHNAN
Entomology Research Unit, Loyola College, Madras,
India 600034

(Received 21 February 1977)

Growth rate and relative growth ratios of various parts of the body of *Eyprepocnemis alacris alacris* (Serville) during post-embryonic development have been studied. The growth rate in terms of weight in different instars, the effect of isolation on weight and growth in terms of length of different parts of the body in relation to eye-stripe number have been discussed.

INTRODUCTION

Diverse aspects of biology and morphometry of Indian acridids have been studied, the principal contributions being those of RAO & GUPTA (1939) on *Acrida*, HUSSAIN & MATHUR (1946) on *Schistocerca gregaria*, AGARWAL (1955) on *Atractomorpha crenulata*, KATIYAR (1955) on *Aularches punctatus* and of ROONWAL (1952) on *Hieroglyphus nigrorepletus* and *Locusta migratoria*. Growth rate in terms of weight is known for *Schistocerca gregaria* (BODENHEIMER, 1929; DAVEY, 1954), *Locusta migratoria migratorioides* (KEY, 1936; DUARTE, 1938), *Melanoplus sanguinipes* (SMITH, 1958) and some British and Canadian grasshoppers (RICHARDS & WALOFF, 1954; PUTNAM & PETERS, 1960). Morphometric studies of non-migratory grasshoppers are limited to those of ROONWAL (1946, 1947), ADAMOVICH (1950), KUNDU & MATHUR (1963). The investigations carried out so far on Indian acridids, do not present a complete picture of the progressive changes and hence an attempt is made to fill this gap. While the duration and gross description of instars of *Eyprepocnemis alacris alacris* (SERVILLE), their food preferences, mandibular and foregut morphology have already been worked out (MURALIRANGAN & ANANTHAKRISHNAN, 1977) the present study aims to elucidate the diverse aspects of growth in relation to weight, length of various structures, eye-stripe number etc., so as to provide a consolidated picture of the progressive changes taking place during post-embryonic development in *Eyprepocnemis alacris alacris* (SERVILLE).

MATERIALS AND METHODS

Eyprepocnemis alacris alacris (SERVILLE) was reared in the laboratory following the technique of MURALIRANGAN (1970). For weighing, a Mettler's semi-micro balance was used. Linear measurements on etherised insects were taken under a stereoscopic microscope. For studying relative growth, HUXLEY's formula (1924) $Y = bx^k$ was used wherein the total length of the body was taken as the standard x, and the length of the hind femora, pronotum, head, epiproct and elytron length for differentially growing parts Y at each development stage and the data fitted to the above formula. The constant K was found out by the method of least squares applied to the formula, $\log Y = \log b + K \log x$, and the log values when plotted would give a straight line graph, from which the value of K could be determined.

[1] Present address: Department of Natural Science, Guru Nanak College, Madras, India 600032

OBSERVATIONS

Growth in terms of weight

Live weight in different instars: Weights of the insects at different stages of development in the case of both sexes is presented in Table 1. It is evident that the rate of increase in weight is rapid in the first four instars and then it sharply declines in the fifth instar and the adult. This holds good for both sexes except for the fact that the rate of increase in weight is greater during third and fourth instars in males than in females. The total weight increase from the first instar to the newly moulted female is 90 times, while it is 75.3 times in males. The pre-oviposition period of the adult which is of short duration ranging from 8–10 days is marked by a gradual increase in weight; this basic weight becomes almost stationary during the oviposition period increasing by then only upto 1.1 times. This therefore represents the mature weight at oviposition. Subsequent to oviposition, a sharp fall in the basic weight has been observed. This is followed by fluctuations above and below the basic weight in relation to successive oviposition. In the case of the males the basic weight is reached within 4–5 days and then the weight fluctuates.

Effect of isolation on weight

In order to estimate the difference in weight of males and females reared in isolation, daily fluctuation of weight was observed. In the case of the mating male (Fig. 1), the maturation period is 5–6 days. The weight increases during maturation by 1.1 times over the weight at emergence in the mated males and then it fluctuates daily between 312.3—373.5 mg. In the case of the unmated males the weight increase is 1.4 times over the emergence weight, fluctuating daily between 323.0—393.0 mg, and just before death, the weight falls below the emergence weight. The maturation period is doubled in the case of unmated

TABLE 1. Mean weight in mg and the rate of increase in weight in various instars of *Eyprepocnemis alacris alacris*.

Stage	No. examined	Female		Male	
		Weight (mg)	[1]Rate of increase	Weight (mg)	[1]Rate of increase
Instar I	25	6.59	..	4.43	..
Instar II	15	10.86	1.65	7.75	1.75
Instar III	20	44.48	4.10	16.65	2.15
Instar IV	25	257.10	5.78	139.60	8.38
Instar V	20	503.70	1.96	233.35	1.65
Adult	20	593.20	1.18	332.68	1.43
Total[2]		..	90.00	..	75.30

[1] Ratio of the weight of the newly moulted instar to that of the newly moulted previous instar.
[2] Total rate of increase of adult over the first instar

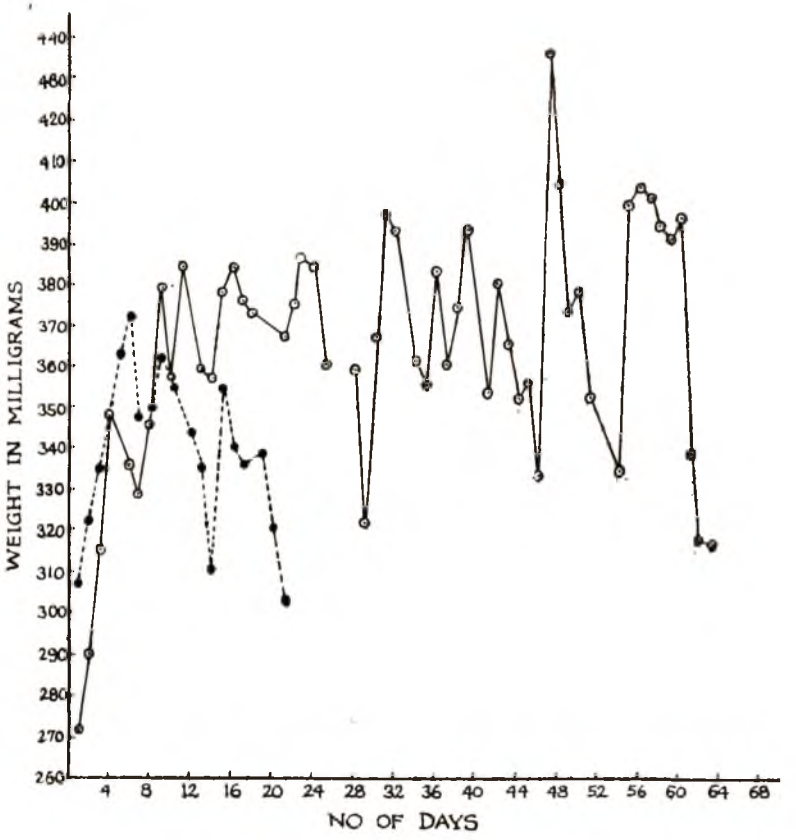


Fig. 1. Weight changes in adult males of *Eyprepocnemis alacris alacris*. ..... Unmated males; ——— Mated males.

males, being 10—11 days as against 4–5 days in the mated males.

In the case of females (Fig. 2), the basic weight is reached in 8–9 days in the mated female. The unmated female also reaches the basic weight in 8–9 days, but the percentage of increase over the emergence weight is different, because the ovarian development is not stimulated. In the mated female the maturation weight is reached in 14–15 days (37.3% over the emergence weight) while in the case of the unmated females, it takes longer time (21–22 days) to reach the maturation weight (51.5% over the emergence weight).

The total life span is also influenced by the presence or absence of the mating pair in the cage. The difference in the case of the female is very meagre whereas the unmated males live longer than the mated ones.

Growth in terms of length

The growth rates of different parts of the body appear irregular throughout. The growth rate of pronotum in the first four instars is higher than the other parts of the body and then there is a slight fall in the rate, with the result the adult pronotum is longer than the pronotum of the fifth

instar. As regard the hind femora, there is a steady growth in length, from the first instar to fifth instar and then the rate falls in the fifth instar and the adult. The length of the elytron is more or less doubled in the fourth to fifth instar and the increase is still more (about three times) from V instar to adult. The female epiproct is longer even from the first instar and from the fifth instar onwards, its growth rate in both sexes is approximately identical.

It has been observed that difference in growth ratios at different stages of development are at time considerable (Figs. 3 & 4). The data also indicate that the growth ratio

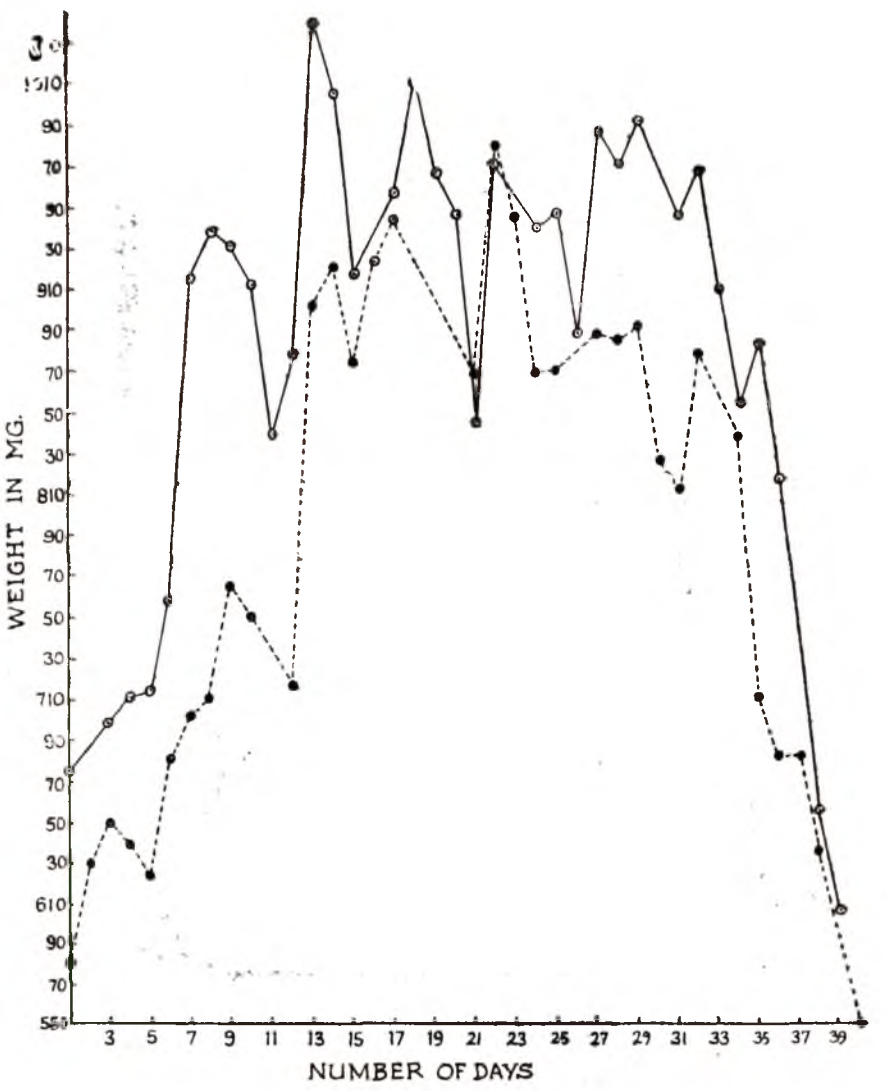


Fig. 2. Weight changes in adult female of *Eyprepocnemis alacris alacris*. ..... Unmated female; ——— Mated female.

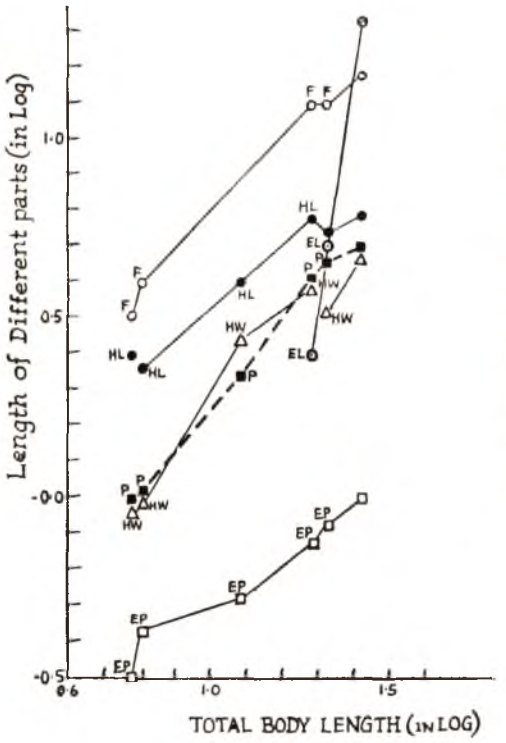


Fig. 3.Graph showing the relative growth ratios (in log values) of different parts of the body in the males of *Eyprepocnemis alacris alacris.*
EL —Elytron length; F —Femoral length;
HL —Head length; P —Pronotum length;
HW —Head width; EP —Epiproct length.

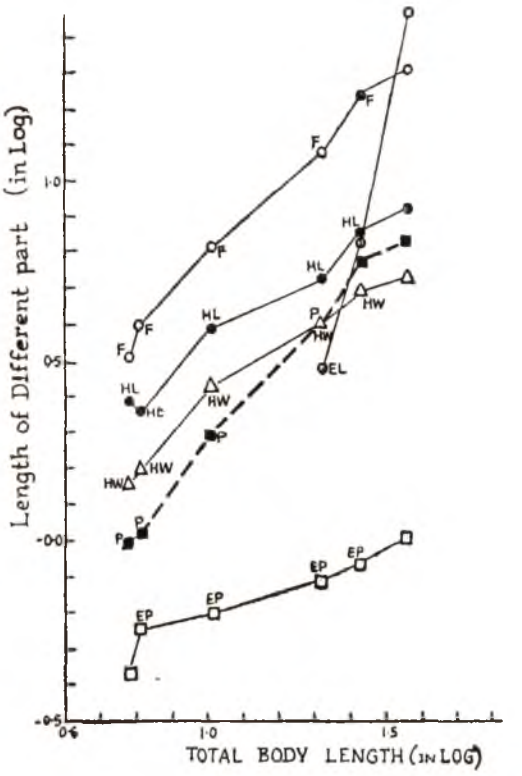


Fig. 4. Graph showing the relative growth ratios (in log values) of different parts of the body in females of *Eyprepocnemis alacris alacris* (lettering as in Fig. 3).

is greater for the males than for the females during the post-embryonic development, with the exception of the hind femoral ratio which is same in both sexes. In addition, the growth rate of the elytron is the greatest in both sexes when compared to other parts of the body.

Growth in relation to the eye-stripe number

In the first instar the eye pigments are found to be scattered at the anterior region and form a faint stripe, which then increases in number to six at the adult stage in both sexes (Fig. 5). It does not have an extra moult and hence the stripe of the instar can be correlated strictly with the number of eye-stripes.

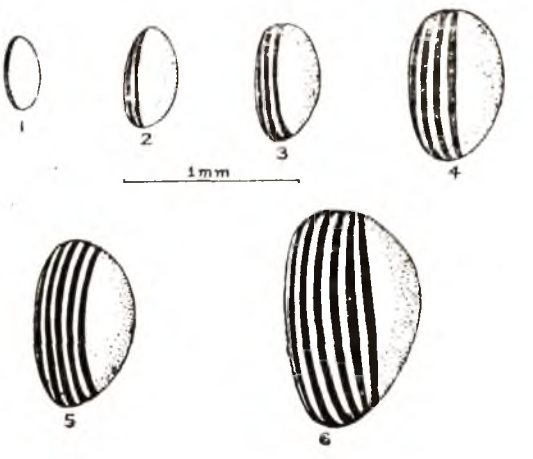


Fig. 5. Number of eye-stripes in *Eyprepocnemis alacris alacris.* 1—5 Instars; 6 Adult.

DISCUSSION

Several attempts have been made to study the rate of growth in acridids (HODGE, 1933, in *Melanoplus differentialis*; SHEPET, 1934, in *Dociostaurus moroccanus*; KEY, 1936, DUARTE, 1938 and CLARKE, 1957, in *Locusta migratoria*; PHIPPS, 1950, in *Locusta migratoria migratorioides*; DAVEY, 1954 and PRADHAN & BINDRA, 1956, in *Schistocerca gregaria*; PUTNUM & PETERS, 1960 for some Canadian grasshoppers; NORRIS, 1959 for *Nomadacris septemfasciata*). The present observations indicate that the weight of *Eyprepocnemis alacris alacris* increases from instar to instar but the rate was found to very between 1.18—5.78 in the females and between 1.43—8.38 in the males. The rate increases during the first four instars with a subsequent fall. After emergence as adults, in both sexes, the weight increases till the basic weight is reached and then the weight fluctuates around the basic weight. In females, the weight increases after copulation till it reaches the maximum weight (mature weight) which then fluctuates. The weight increase during maturation period is associated with the development of the reproductive organs and fat bodies (RICHARDS & WALOFF, 1954). As is expected, the rate of increase in weight is greater in females of *Eyprepocnemis alacris alacris* but this is not so in *Locusta* and *Schistocerca*.

Isolated males and females take longer time to mature. In addition, the unmated males live longer than the mated males but this does not apply to females. Hence it may be concluded that because of the presence of the males, the maturation period is shorter, resulting in quick development of the reproductive organs, while it is slow in the case of unmated ones.

In the morphometric study of *Eyprepocnemis arlacris alacris*, it was noted that the relative growth ratio for the length of the hind femora is the same in both sexes, while generally the growth ratios for the other parts discussed are always higher in males than in females until the third instar. Further, it shows that the growth rate of all the parts considered increases (in females) or decreases (in males) after the fourth instar. The growth rate of the pronotum is found to be higher in the first four instars, with a decline in the fourth and fifth instars in contrast to *Locusta* where there is a sharp fall resulting in a smaller pronotum in the adult than that of the fifth instar (DUARTE, 1938).

The eye pigmentation has proved to be of value in determining and identifying the number of nymphal instars. Since one stripe is added at every moult, the number of stripe in the adult indicates the number of nymphal instars. The eye-stripes have been studied only in some locusts and a few grasshoppers *viz. Schistocerca* (MUKERJI & BATRA, 1938; VOLKONSKY, 1938 and ROONWAL, 1947); *Anacridium aegyptium* and *A. melanorhodon* (VOLKONSKY, 1938); *Nomadacris* (BURNETT, 1951; ALBRECHT, 1955) and some Indian acridids (RAO & GUPTA, 1939). ANTONIOU & HUNTER JONES (1956) studied *Eyprepocnemis capitata* and determined 6, 7 and 8 instar life-cycle for both sexes while JAGO (1963) found only 7 for males and 7-8 for females of *Eyprepocnemis plorans meridionalis* with the help of the eye pigmentatin character. The former author based his observation only on the eye-stripe character, which is liable to be misinterpreted. JAGO (1963) based his results on various other characters such as the rotation of the wing rudiment, genital structure etc. in addition to the eye-stripe character. In the present studies the eye-stripe number corresponds with the number of instars and each stripe is independent of the other in contrast to *Eypre-*

pocnemis plorans moridionalis, where when it moults to the adult stage, the second anterior stripe fuses with the first to form a single thick band (JAGO, 1963).

Acknowledgements:– Our thanks are due to Prof. BALASUBRAMANIAN, Department of Statistics, Loyola College, Madras for help in the statistical analysis.

REFERENCES

ADAMOVICH, Z. R. (1950) Quelques analyses biometriques de *Oedipoda caerulescens* (L.). *Glas. Muz. srp. Zeml.*, **3** & **4 B** : 333–342.

AGARWAL, N. S. (1955) Bionomics of *Atractomorpha crenulata* FAB. *Indian J. Ent.*, **17** : 230–240.

ALBRECHT, F. O. (1955) La densité des population et la croissance chez *Schistocerca gregaria* (Forsk.) et *Nomadacris septemfasciata:* la mue d'ajustmement. *J. Agric. trop. Bot. appl.*, **2** : 109–192.

ANTONIOU, A. & P. HUNTER JONES (1956) The life history of *Eyprepocnemis capitata* MILLER in the laboratory. *Entomologist's mon. Mag.*, **92** : 364–368.

BODENHEIMER, F. S. (1929) Studien zur Epidemiologie, Ökolagie und Physiologie der Afrikanischen Wanderheuscherecke (*Schistocerca gregaria* FORSK). *Z. angew. Ent.*, **15** : 435–557.

BURNETT, G. F. (1951) Observations on the life history of the Red Locust, *Nomadacris septemfasciata* (SERV.) in the solitary phase. *Bull. ent. Res.*, **42** : 473–490.

CLARKE, K. V. (1957) On the increae in the linear size during growth in *Locusta migratoria* L. *Proc. R. ent. Soc. Lond.*, **32** : 35–39.

DAVEY, P. M. (1954) Quantities of food eaten by the Desert Locust, *Schistocerca gregaria* (FORSK.) in relation to growth. *Bull. ent. Res.*, **45** : 539–551.

DUARTE, A. J. (1938) Problems of growth of the African Migratory Locust. *Bull. ent. Res.*, **29** : 425–446.

HODGE, C. (1933) Growth and nutrition of *Melanoplus differentialis* THOMAS. 1. Growth on a satisfactory diet and on diets of single food plants. *Physiol. Zool.*, **6** : 306–328.

HUSSAIN, M. A. & C. B. MATHUR (1944) Studies on *Schistocerca gregaria* (FORSK.). XI. The influence of temperature on growth in weight and size of the hoppers. *Indian J. Ent.*, **5**: 107–115.

HUSSAIN, M. A. & C. B. MATHUR (1946) Studies on *Schistocerca gregaria* (FORSK.) XII. Sexual life. *Indian J. Ent.*, **7** : 89–101.

HUXLEY, J. (1924) Constant different growth ratios and their significance. *Nature*, **114** : 895.

JAGO, N. D. (1963) Some observations in the life cycle of *Eyprepocnemis plorans meridionalis* UV. 1921 with a key for the separation of nymphs at any instar. *Proc. R. ent. Soc. Lond.*, **38** : 113–124.

KATIYAR, K.M. (1955) The Life-history and ecology of the Northern spotted grasshopper, *Aularches punctatas* DRURY. *Agra Univ. J. Res.* (*sci.*), **4** : 397–413.

KEY, K. H. L. (1936) Observations on the rate of growth, coloration and the abnormal six instar life-cycle in *Locusta migratoria migratorioides* R & F. *Bull. ent. Res.*, **27** : 77–85.

KUNDU, H. L. & C. B. MATHUR (1963) Morphometric studies in some acridids. *Indian J. Ent.*, **25** : 161–171.

MURALIRANGAN, M. C. (1970) Studies on some acridids from South India. Ph. D. Thesis, Madras University, India.

MURALIRANGAN, M. C. & T. N. ANANTHAKRISHNAN (1977) Studies on the biology of *Eyprepocnemis alacris alacris* (Serv.). *Indian J. Ent.*, (in press)

MUKERJI, S. & R. N. BATRA (1938) A note on the post-embryonic development of eye-stripes and their correlation with number of larval instars and the antennal segments in the life-cycle of *Schistocerca gregaria* (FORSK.). *C. R. 5th Cong. Int. Rech.*, Brussels.

NORRIS, M. J. (1959) Reproduction in Red Locust (*Nomadacris septemfasciata* (SERV.) in the laboratory. *Anti-Locust Bull.* No. 36, 46 pp.

PHIPPS, J. (1950) The maturation of the ovaries and the relation between weight and maturity in *Locusta migratoria migratorioides* (R. & F.). *Bull. ent. Res.*, **40** : 539–557.

PRADHAN, S. & O. S. BINDRA (1956) Studies on resistance to contact toxicity of Gamma-BHC suspensions by successive instars of *Schistocerca gregaria* (FORSK.) and certain associated factors. *Indian J. Ent.*, **18** : 93–111.

PUTNAM, L. G. & E. G. PETERS (1960) The growth characteristics in terms of live weight of some grasshoppers of Western Canada. *Can. Ent.*, **92** : 908–910.

RAO, Y. R. & R. L. GUPTA (1939) Some notes on the eye-stripes in Acrididae. *Indian J. agric. Sci.*, **9** : 727–729.

RICHARDS, O. W. & N. WALOFF (1954) Studies on the biology and population dynamics of British Grasshoppers. *Anti-Locust Bull.*, **17** : 182 pp.

ROONWAL, M. L. (1946) Studies in intraspecific variation. II. New rules governing the correlation between normal and extra moulting and directional reversal of the elytron-wing complex in the Desert Locust and other Acrididae. *Indian J. Ent.*, **7** (1945) : 77–84.

ROONWAL, M. L. (1947) Variation and structure of the eyes in the Desert Locust, *Schistocerca gregaria* (FORSK.). *Proc. R. ent. Soc. Lond.*, **134B** : 245–272.

ROONWAL, M. L. (1952) Variation and post-embryonic growth in the number of antennal segments in the phadka grasshopper (*Hieroglyphus nigrorepletus* BOLIVER), with remarks on the Desert Locust and other Acrididae (Insecta : Orthoptera). *Proc. natn. Inst. Sci. India*, **18** : 217–232.

SHEPET, G. (1934) On the problems of insect growth. *Zool. zh.*, **13** : 195–206.

SMITH, D. S. (1958) Utilisation of food plants by the migratory grasshopper, *Melanoplus bilituratus* (WALK.) with some observations on the nutritional value of the plants. *Ann. ent. Soc. Am.*, **52** : 674–680.

VOLKONSKY, M. A. (1938) Sur la formation des stries ocularres chez les Acridiens. *C. r. Seanc. Soc. Biol.*, **129** : 154–157.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 201 *to* 208

LARVAL MORPHOLOGY OF SOME LEAF-EATING PESTS OF RICE

SANJIB CHAKRAVORTY & PHANINDRA KUMAR MANDAL
Department of Zoology, University of Kalyani, Kalyani, West Bengal, India

(*Received 12 February 1977*)

Morphology and chaetotaxy of the mature larvae of *Nymphula depunctalis* Guen., *Susumia exigua* Btlr., *Brachmia arotraea* Meyr. and *Pelopidas mathias* Fab. are described.

The four leaf-eating lepidopteran larvae of *Nymphula depunctalis* Guen. (Pyraustidae), *Susumia exigua* Btlr. (Pyralidae), *Brachmia arotraea* Meyr. (Gelechiidae) and *Pelopidas* (*Parnara*) *mathias* Fab. (Hesperiidae) are much injurious to rice plants (Sen & Chakravorty, 1969). The differences in their nest-forming behaviour were investigated by Sen & Chakravorty (1970). This communication, dealing with their identifying characteristics, has been made after a detailed morphological study of the ultimate instar larvae.

The larvae were collected from the rice plants in the field and were killed in hot water in fully stretched condition. Permanent acid fuchsin stained slides of head capsules, mouth parts and skins were prepared afer treatng them in 10 per cent KOH. Temporary slides, in modified Hoyer's medium (Composition : distilled water 50 ml, gum arabic 50 gm, chloral hydrate 125 gm, glycerine 39 ml), were also prepared for microscopic study.

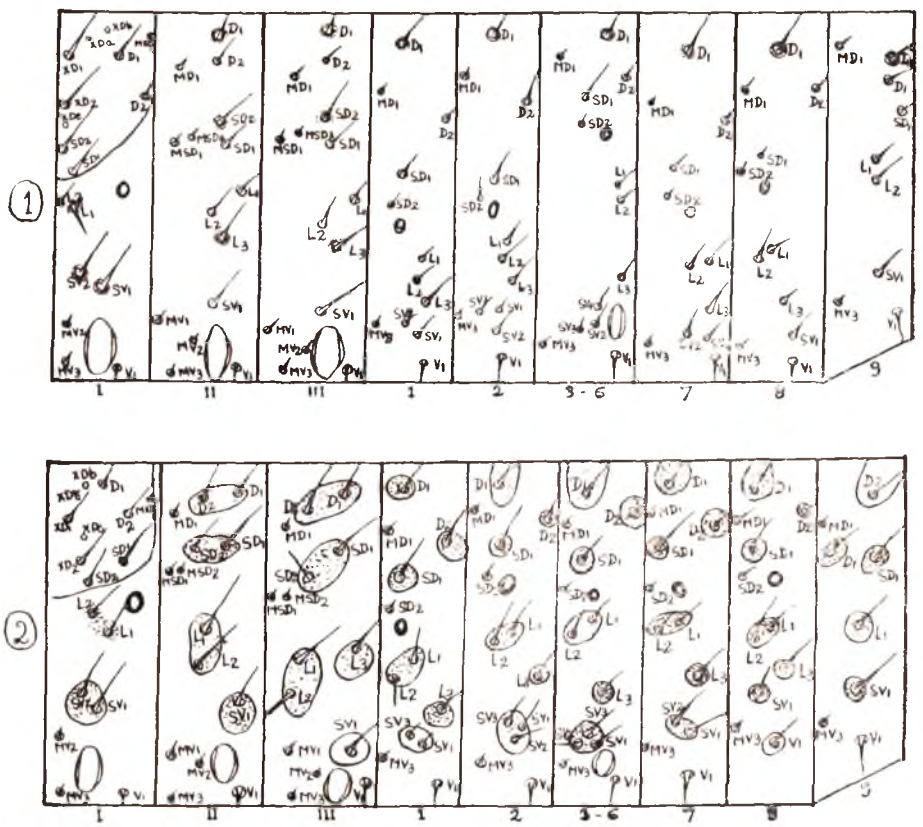
The setal nomenclature of Hinton (1946), Heinrich (1916) and Forbes (1910) was adopted for head and skin, labrum and maxilla respectively. While naming some setae in the thoracic and abdominal segments, McGuffin (1964) and Mackay (1972) were followed. The general larvel description followed that of Peterson (1959).

Nymphula depunctalis Guen.

Length 14.0—15.0 mm, width 1.5—2.0 mm. Body greenish white, venter white, head brown, prothoracic shield distinct and deep-brown, suranal shield light-brown, legs and prolegs brown. Integument smooth with large simple type of tactile setae and long tubular tracheal gills. Head capsule 0.855—0.950 mm long, 0.950—1.108 mm wide, adfrontal sutures meet tip of coronal suture. Antennae 0.266—0.304 mm long. Labrum 0.190—0.209 mm antero-posteriorly, 0.285—0.304 mm laterally. Seta M1 nearest to midline. M2 and M3 respectively dorso-lateral and antero-lateral to M1. These are almost at same distance from midline. Lateral setae present on lateral margins of labrum. Epipharyngeal setae, three in each side, present. One puncture present on each of lateral sides of labrum. Two disto-lateral regions of labrum sparsely covered with spinules which are cephalad and cephalo-mesal in direction. Proximo-medial region of labrum densely covered with caudally directed spinules. Depth of labral notch moderate. Sides of notch on anterior margin of the labrum form an angle of about 100°. Mandibles 0.228—0.266 mm long, 0.228—0.247 mm wide. Along distal margin of mandible there are five teeth of which three are sharp and two blunt. Mandible bears two setae on outer side, proximal

seta being longer than distal one. Tooth-like retinaculum present. Maxillae 0.570—0.608 mm long, form lateral sides of maxillolabial - hypopyaryngeal complex, width of complex, 0.532—0.608 mm, spinneret flat and short with an open apical silk pore. Lingua separated from the maxillary lobe by a transverse deep-brown sclerotised wavy line. Maxillulary teeth minute spines like and arranged in densely set rows. Proximo-medial region of hypopharynx bears a few laterally directed minute spines which are caudo-mesal and mesal in direction. Limits of gorge not well defined. Mentum bears two setae. Stipes bears a few setae and one aperture.

Length/width of oval shaped throacic spiracles 0.028—0.035 mm/0.021—0.028 mm. Peritremes on both cephalic and caudal sides almost of equal thickness. They are light brown-rimmed with ground coloured centre. The length/width of abdominal spiracles 0.021—0.140 mm/0.021—0.105 mm. Eighth abdominal spiracles largest. They are similar in structure with those of thoracic spiracles. Prolegs of uniform shape and size. Abdominal crochets biordinal circle. Anal crochets biordinal, mesal penallipse. Their number varies. Crochets numbering 56—65, 60—70, 60—70, 63—78 and 48—72 present in the first, second, third, fourth and anal prolegs respectively.



Figs. 1 — 3. Setal maps of thoracic (Roman numerals) and abdominal (Arabic numerals) segments of *Nymphula depunctalis* (1), *Susumia exigua* (2) and *Brachmia arotraea* (3, p. 203).

Figs. 1A — 3A. Setal maps of cranii of *Nymphula depunctalis* (1A), *Susumia exigua* (2A) and *Brachmia arotraea* (3A).

Chaetotaxy (Figs. 1 & 1A): XD1 and XD2, present only on prothorax, long and almost equal in length. XD1 dorsal to XD2. Aperture XDa dorso-caudal to XD1, and XDb dorso-caudal to XDa. XDc ventral to XD2. In prothorax D1 dorso-cephalad to D2. The two setae present on the caudal margin of prothoracic shield. In meso- and metathorax D1 dorsal to D2. The basal area of D1 brown. In first eight andominal segments D1 dorso-cephalad to D2 but in ninth abdominal segment D2 dorsal to D1. The basal areas of D1 in first eight abdominal segments and of D2 in ninth abdominal segment light-brown. In prothorax SD1 and SD2, present on the cephalic side of the prothoracic shield, equal in length and well-separated. In meso- and metathorax these two setae well separated. In thoracic segments SD1 much thin and fibre-like. SD1 in prothorax longer than the meso- and metathoacic SD1. In meso- and metathorax basal area of SD2 brown. In abdominal segments SD2 much small. With respect to SD2 position of SD1 is ventro-caudal in prothorax, ventral in meso- and metathorax and dorso-caudal in first eight abdominal segments. Only seta SD1, which is almost similar to that of prothroacic SD1 in thinness, representing SD group in ninth abdominal segmnt, is ventro-caudal to D1. In prothrox and ninth abdoninal segment L1 and L2 present and L3 absent. In all other thoracic and abdominal segments L1, L2 and L3 present. In prothorax L group pesent on the cephalic side of the spiracle with L1 ventro-caudal to L2.

L2 slender; basal area of L1 brown. In meso- and metathorax L1 dorso-caudal to L2, and L3 ventro-caudal to L2; basal area of L3 brown. In first through eighth abdominal segments L1 ventral to spiracle, and L2 ventro-cephalad to L1; L3 ventro-caudal to L2. In ninth abdominal segment, L1 and L2 ventrocephalad to SD1 where L1 dorsal to L2. Sub-ventral group bisetose /(SV1 and SV2) in prothorax and seventh abdominal segment; unisetose (SV1) in meso-, metathorax, eighth and ninth abdominal segments; trisetose (SV1, SV2 and SV3) from second through sixth sabdominal segments. In first abdominal segment SV2 absent, SV1 and SV3 present. In prothorax the setae of this group ventro-cephalad to spiracle, SVI being ventro-caudal to SV2. Basal areas of the two setae light-brown ringed. In meso- and metathorax SVI seta dorsal to coxal base. In first and second abdominal segments SVI ventro-caudal to SV3. SV2, in second abdominal segment, ventral to SV1. In proleg bearing segments this group is on cephalic side of prolegs. In seventh abdominal segment SV2 dorso-cephalad to SV1. In eighth abdominal segment SV1 ventro-caudal to L3. In ninth abdominal segment SVI ventral to L2. V1 representing V group is ventralmot. Three microscopic setae in prothorax present. MXD1, present on caudo-mesal margin of prothoroacic shield, dorso-caudal to D1. MV2 and MV3 respectively dorso-cephalad and ventro-cephalad to coxal base. Six microscopic setae present in meso- and metathorax towards cephalic margin. MD1 dorsalmost micro-seta. MSD1 and MSD2 below-MD1. MV1, MV2 and MV3 dorso-cephalad to coxal base. Two micro-setae, MD1 and MV3, present in abdominal segments. In each segment MD1 cephalo-dorsal and MV3 ventro-cephalad in position. MD1 always ventro-cephalad to D1, MV3 dorso-cephalad to V1. Two setae C1 and C2 present in ventro-lateral region of clypeus. C2 dorso-medial to C1. Seta F1 present in ventro-lateral corner of frons. Puncture Fa mesad and lies below the level of F1. AF2 behind and slightly mesad from AF1. Puncture AFa on the line joining two setae AF1 and AF2 and slightly closer to AF2. A1 near and lateral to C1. A2 behind A1. A3 lateral to A2. Aa lateral to A2. 01 very close and lateral to ocellus-III. 02 dorso-lateral to 01 and lies behind ocellus-I. 03 far behind 01 and lies at a distance from ocellus-VI. Puncture 01 situated between ocelli-I and -VI. Another puncture 0b present close to ocellus-IV. Among sub-ocellar setae S01 anteriormost. S02 lies near ocellus-V and S03 behind S01. S0a lies between S02 and S03. L1 lies far above ocellus-I, behind and above A3. La lies beyond L1. P1 close to adfrontal region. P2 lies above and posterior to P1. Pb lies between P1 and P2. Puncture Pa much anteriorly situated and lies near seta A2. VI near P2 and V2 lies between V1 and V3. V3 topmost seta. Va present between V2 and V3. G1 lies beyond 03. Ga lateral to G1.

Susumia exigua Btlr.

Length 8.0—10.0 mm, width 1.0—1.2 mm. Body pale-yellow or whitish. Ingested green leaf tissue in digestive tract often gives the larva a greenish colouration. Venter white. Head deep-brown. Prothoracic shield distinct and deep-brown, suranal shield brown. Legs and prolegs brown. Integument smooth. Large simple type of tactile setae present. Head capsule 0.756—0.918 mm long, 0.810—0.972 mm wide. Adfrontal sutures meet tip of coronal suture. Antennae 0.198—0.270 mm long. Labrum 0.180—0.216 mm antero-posteriorly, 0.306—0.340 mm laterally. Setal pattern in labrum similar to that in *Nymphula*. Two punctures present on each side of labrum. Two small

areas in proximo-lateral regions covered with minute spinules which are caudo-mesal in direction. Proximo-medial region of labrum covered with caudally directed spinules. Depth of labral notch and angle thus formed same as in *Nymphula*. Mandibles 0.270—0.306 mm long, 0.198—0.216 mm wide. Along distal margin of mandible there are four sharp teeth. Mandibular setae similar to those in *Nymphula*. Retinaculum absent. Maxillae 0.684—0.846 mm long. Width of complex 0.504—0.576 mm. Maxillulary teeth slender and long spines like, densely set and arranged in two rows which are continuous with minute slender and densely set spines of distal region of hypo-pharynx. These spines caudo-mesal in direction. Stipes bears only a few setae. Other features of complex similar to those in *Nymphula*. Thoracic spiracles almost similar to those of *Nymphula*, they differ only in size. The length/width of these spiracles 0.075—0.090 mm/0.060—0.075 mm. Abdominal spiracles similar to those of *Nymphula* in all respects. Prolegs of uniform shape and size. Abdominal crochets bi-ordinal, mesal penellipse. Anal crochets biordinal, and arranged in homodeus meso-series, but their number varies. Crochets numbering 25—27, 25—29, 25—29, 24—27 and 18—32 present in first, second, third, fourth and anal prolegs respectively.

Chaetotaxy (Figs. 2 & 2A) : XD1 and XD2, present only on prothorax, long and almost equal in leghth. XD1 dorsal to XD2. Aperture XDa dorso-caudal to XD1, and XDb dorso-caudal to XDa. XDc ventro-caudal to XD1 and dorso-caudal to XD2. In prothrox D1 dorso-cephalad to D2 and present on the caudal margin of prothoracic shield. In meso- and metathorax D1 dorso-caudal to D2 and on a common pinaculum. In first eight abdominal segments D1 dorso-cephalad to D2, but in ninth abdominal segment D2 dorso-caudal to D1. D-group setae in abdominal segments on separate pinacula. In prothorax SD1 and SD2 almost equal in length and well separated, present on the mesal side of prothoracic shield. In meso- and maetathorax the two setae well-separated. In all thoracic segments SD1 much thin and fibre-like. In meso- and metathorax SD1 and SD2 on a common pinaculum. In abdominal segments SD2 much small. With respect to SD2, positon of SD1 dorso-caudal in thoracic and first eight abdominal segments. The only seta SD1 which is almost similar to that of thoracic SD1 in thinness, representing SD group in ninth abdominal segment, ventral to D2. In abdoninal segments SD1 present on pinaculum. In prothorax L1 and L2 present, L3 absent. In ninth abdominal segment only L1 present, L2 and L3 absent. In all other thoracic and abdominal segments L1, L2 and L3 present. In prothorax L group present on cephalic side of spiracle where L2 dorso-cephalad to L1; L2 slender; bases of the setae surrounded by a common brown area. In meso- and metathorax L1 dorso-caudal to L2, and L3 dorsocaudal to L1; L1 and L2 on a common pinaculum, L3 on a speparate pinaculum. In first eight abdominal segments L1 ventral to spiracle, and L2 ventro-cephalad to L1; L3 ventro-caudal to L2; L1 and L2 on a common pinaculum, L3 on a separate pinaculum. In ninth abdoninal segment L1 ventral to SD1; L1 on the pinaculum. Sub-ventral group bisetose (SV1 and SV2) in prothorax and seventh abdominal segment; unisetose in meso- and metathorax, eighth and ninth abdominal segments; trisetose (SV1, SV2 and SV3) in second through sixth abdominal segments. In first abdominal segment SV2 absent, SV1 and SV3 present. In prothorax SV group of setae ventro-cephalad to spiracle, SV1 being ventro-caudal to SV2; bases of two setae on common pinculum. In meso- and metathorax SV1 seta dorsal to the

coxal base; SV1 on the pinaculum. In first two abdominal segments SV1 ventro-caudal to SV3. SV2 in second abdominal segment ventro-cephalad to SV1. They are on common pinaculum in first two abdominal segments. In proleg bearing segments they ared orso-cephalad to prolegs. SV1 ventro-caudal to SV3, and SV2 ventro-cephalad to SV1; they are on a common pinaculum. In seventh abdominal segment SV1 ventro-caudal to SV2; they are on a common pinaculum. In eighth abdominal segment SV1 ventro-cephalad to L3. In ninth abdominal segment SV1 ventral to L1. SV1 in both eighth and ninth abdominal segments set on pinaculum. Single seta V1 representing V group ventralmost, and ventral to prolegs in third through sixth abdominal segments. Three microscopic setae present in prothorax. MXD1, present on caudo-mesal margin of prothoracic shield, ventro-caudal to D1 but dorso-caudal to D2 and nearer to D2. MV2 and MV3 are respectively dorso-cephalad and ventro-cephalad to coxal base. Six microscopic setae present in meso- and metathorax towards cephalic margin of each segment. MD1 is dorsalmost microseta. MSD1 and MSD2 lie below MD1. MV1 and MV2 dorso-cephalad and MV3 ventro-cephalad to costal base. Two micro setae, MD1 and MV3, presnet on abdominal segments. In each segment MD1 cephalao-dorsal and MV3 cepaholo-ventral in position. MD1 always ventro-cephalad to D1. MV3 dorso-cephalad to V1. Distribution of cranial setae is almost similar to that of *Nymphula* except the following minor vriations : the distance between A1 and A2 is greater than the distance between A2 and 3: Aa is ventro-lateral to A2; puncture 0a situated between ocellus-VI and seta 02; S02 lies near ocellus VI; S0a lies between S03 and S01; G1 lies beyond 02.

Brachmia arotraea Meyr.

Length 8.0—10.0 mm, width 1.0—1.2 mm. Looks greenish due to ingested leafy tissues in digestive tract. Dorsum of body possesses light-brown longitudinal stripes. Thoracic segments deep-brown. Venter light-yellow. Head deep-brown. Prothoracic shield distinct and deep-brown. Suranal shield light-brown. Legs and prolegs brown. Integument smooth. Long simple type of tactile setae present. Head capsule 0.600—0.675 mm long, 0.675—0.750 mm wide. Adfrontal sutures meet tip of coronal suture. Antennae 0.075—0.120 mm long. Labrum 0.195—0.225 mm antero-posteriorly, 0.120—0.135 mm laterally. M1 nearest to midline. M2 and M3 respectively lateral and antero-lateal to M1 and are almost at same distance from midline. Lateral setae present on the lateral margins of labrum. Epipharynageal setae, three in each side, present. One puncture present on lateral side of labrum. Two antero-lateral areas of labrum sparsely clothed with minute spinules. These are mesal in direction In mesal region also threre are spinules which are caudal in direction. Depth of labral notch moderate. Sides of notch on anterior margin of labrum form an angle of about 90°. Mandibles 0.195—0.225 mm long, 0.120—0.135 mm wide. It bears six teeth of which two sharp and four blunt. Other characters of the mandible same as *Susumia*. Maxillae 0.450—0.525 mm long. Width of complex ranges from 0.375—0.480 mm. Maxillulary teeth are slender, short and very densely arranged; these are mesal and caudo-mesal in direction. Medial region of hypopharynx provided with minute spinules. These spinules are caudo-mesal, mesal and frontal in direction. Other characters of complex similar to those in *Susumia*. Length/width of thoracic spiracles 0.048—0.064 mm/0.040—0.056 mm. They are otherwise similar to those of *Nymphula*. Length

width of abdominal spiracles 0.032—0.064 mm/0.032—0.056 mm. Spiracles are dark-rimmed. In other features they are similar to those of *Nymphula*. Prolegs of uniform shape and size. Abdominal crochets biordinal, arranged in two transverse bands. Anal crochets on each anal prolegs arranged in a single band of crochets broken into two groups. Crochets numbering 11—15, 9—17, 10—17, 10—15, 12—14 and 10—13, present in first, second, third, fourth and anal prolegs respectively. Anal fork consists of 5 well developed sharp prongs.

Chaetotaxy (Figs. 3 & 3A) : XD group similar to that of *Susumia*. In prothorax D1 dorsal to D2; two setae are on caudal margin of prothoracic shield. In meso- and metathorax D1 dorsocephalad to D2; in meso- and metathorax bases of D1 and D2 on separate deep-brown areas. In first eight abdominal segments D1 dorso-cephalad to D2 but in ninth abdominal segment D2 dorso-caudal to D1; their basal areas deep-brown. Arrangement of setae of SD and SV groups similar to that of *Susumia:* only difference is that in *Brachmia* there is no distinct pinaclum, basal areas of setae deep-brown. In thoracic and first eight abdominal segments L1, L2 and L3 present. In ninth abdoninal segment L3 absent and only L1 and L2 present. In prothorax this group ventro-cephalad to spiracle where L2 dorso-cephalad to L1, and L1 ventro-cephalad to L3: they are present on a common light-brown area. In meso- and metathorax L1 dorso-caudal to L2, and L3 dorso-caudal to L1; L1 and L2 on a common brown area but L3 on a separate pigmented area. With respect to the spiracle, position of L1 ventro-caudal to spiracle in first seven abdominal segments. In eighth abdominal segment L1 ventro-cephalad to spiracle. In first eight abdominal segments L2 ventro-cephalad to L1, and L3 ventro-caudal to L2. In ninth abdominal segment L1 ventro-caudal to SD1, and L2 cephalad to L1. In all abdominal segments L1 and L2 on a common pigmented area. L3 on separate pigmented area. V group same as in *Susumia*. Distribution of thoracic and abdominal micro-setae similar to that of *Susumia*; the cranial setae, however, differ from the same in the following points : 01 very close and lateral to ocellus-II; puncture 0a anterior to 03; S0a lies between S01 and S02; G1 lies beyond 03; Ga dorsal to G1.

Pelopidas mathias Fab.

Length 23.0—27.0 mm, width 3.5—4.0 mm. Body greenish. A deep-green longitudinal line present on mid-dorsal region. Larva characterised by a constricted neck and 'V' shaped red markings on head. Venter pale-green. Head brown. Frons and adfrontal regions marked with white lines in the form of inverted 'V's. Vertex and gena deep-brown. Thoracic shield distinct and light-brown. Suranal shield light-brown. Legs and prolegs light-brown. Integument clothed with stout spinules, much spinulation present on legs and prolegs. Head capsule 1.50—1.65 mm long, 1.47—1.65 mm wide. Adfrontal sutures meet lower half of coronal suture. Antennae 0.765—0.795 mm long. Labrum 0.270—0.300 mm antero-posteriorly, 0.330—0.375 mm laterally. Distribution of medial and lateral setae and punctures similar to that of *Susumia*. Proximo-medial region of labrum sparsely covered with spinules arranged in two groups. These spinules caudal and caudo-mesal in direction. Depth of labral notch moderately shallow. Sides of notch on anterior margin of labrum form an angle of about 120°. Mandibles 0.375—0.450 mm long, 0.480—0.525 mm wide. Distal margin of mandible smooth. It bears four setae on outer side. Retinaculum

absent. Maxillae 0.525—0.675 mm long. Width of complex ranges from 0.450—0.525 mm. Maxillulary spines caudal in direction. Stipes bears a good number of setae (7—8). Other features of complex similar to those in *Nymphula*. Length/width of thoracic spiracles 0.312—0.364 mm/0.260—0.266 mm. Peritreme on cephalic side thicker than that of caudal side. In other features thoracic spiracles similar to those of *Nymhula*. Length/width of abdominal spiracles 0.182—0.364 mm/0.130—0.234 mm. Eighth abdominal spiracles largest. They are similar in structue with those of thoracic spiracles. Prolegs of uniform shape and size. Abdominal crochets triordinal and arranged in an irregular but complete circle. Anal crochets triordinal mesoseries. Their number varies. Crochets innumerable (more than 86). Anal fork comb like with 16—18 small blunt prongs.

Chaetotaxy : Numerous short secondary setae present over he integument and head capsule. These are more or less distributed over entire body. Bases of setae pigmented. Some of the setae are large while others are small.

Acknowledgements :- The authors are thankful to Professor G. K. MANNA, Head of the Department of Zoology, Kalyani University for providing laboratory facilities. The authors are grateful to Professor D. K. CHOUDHURI, Head of the Dpeartment of Zoology, University of Burdwan, West Bengal for kindly going through the manuscript. Thanks are also due to: the Director, Zoological Survey of India, Calcutta for identifying the adult insects; the University of Kalyani for financial assistance.

REFERENCES

FORBES, W. T. M. (1910) A structural study of some caterpillars. *Ann. ent. Soc. Am.*, **3**: 94–143.

HEINRICH, C. (1916) On the taxonomic value of some larval characters in the Lepidoptera. *Proc. ent. Soc. Wash.*, **18** : 154–164.

HINTON, H. E. (1946) On the homology and nomenclature of the setae of Lepidopteran larvae, with some notes on the phylogeny of the Lepidoptera. *Trans. R. ent. Soc. Lond.*, **97** : 1–37.

MACKAY, M. R. (1972) The larvae of Canadian Arctic Noctuidae (Lepidoptera). *Can. Ent.*, **104** : 859–872.

MCGUFFIN, W. C. (1964) Setal patterns of the anterior abdominal segments of larvae of the Geometridae (Lepidoptera). *Can. Ent.*, **96** : 841–849.

PETERSON, A. (1959) *Larvae of insects. Part I. Lepidoptera and plant infesting Hymenoptera.* Edwards Brothers Inc., Ann. Arbor, Michigan: 315 pp.

SEN, P. & S. CHAKRAVORTY (1969) Insect pests of rice plant in Haringhata (Nadia, West Bengal); Field surveys and Bionomics, *Proc. natn. Acad. Sci. India*, **39 B**: 261–270.

SEN, P. & S. CHAKRAVORTY (1970) Mode of formation of larval shelters in certain Lepidopterous pests of rice. *Int. Rice Commn. Newsl.*, **19** : 13–19.

Entomon, 1977, *Vol.* 2. *No.* 2, *pp* 209 *to* 213

DISTRIBUTIONAL PATTERNS OF INDIAN VESPIDAE (HYMENOPTERA) WITH REFERENCE TO ALTITUDE

V. K. GUPTA & BINA PANI DAS
Department of Zoology, University of Delhi,
Delhi, India 110007

(*Received 20 August 1977*)

The patterns of distribution of Indian Vespidae (Hymenoptera) are analyzed in relation to the altitude. There are 9 genera occurring in India. The Vespidae are most abundant in Zone I, II and III. Of the 9 genera, *Vespa* Linnaeus and *Polistes* Latreille are the most abundant genera. The genus *Polistes* is widely distributed throughout the world. In the genera *Stenogaster* Guerin, *Ropalidia* (Saussure), *Polistes* Latreille and *Vespa* Linnaeus, the maximum number of species are present in Zone I and number of species gradually diminishes in the higher Zones, except for *Stenogaster* which is distributed upto Zone II. While in the case of *Parapolybia* Saussure and *Paravespula* Bluthgen the maximum number of species are present in Zone II and III respectively, the number of species diminishing in both the lower and the higher altitudes. *Belonogaster* Saussure is present only in Zone I and *Provespa* Ashmead is restricted only to Zone III, whereas *Dolichovespula* Rohwer is localized in the higher Zones V and VII.

The family Vespidae commonly known as the paper wasps, hornets or yellow jackets are predators of many agricultural pests. They are widely distributed in the world and so far 64 species have been reported from India (Bingham, 1897; Liu, 1936-1937; Vecht, 1941, 1957, 1959, 1962). Yet we have no information on their patterns of distribution in various altitudinal Zones in India. The distributional ranges of the species so far known and collected by a team of workers at the University of Delhi are analyzed and the findings are reported below.

The following Zones have been recognised for analyzing the distribution of Indian Vespidae. Zone I, from sea level up to 1,000 metres; Zone II, from 1,000 metres to 1,500 metres; Zone III from 1,500 metres to 2,000 metres; Zone IV, from 2,000 metres to 2,500 metres; Zone V, from 2,500 metres to 3,000 metres; Zone VI, from 3,000 metres to 3,500 metres; Zone VII, from 3,500 metres to 4,000 metres. Zone I includes the plains of India, Zone II corresponds to the foot hills or submontane region, Zone III to the montane region, Zones IV and V exhibit alpine conditions and Zones VI and VII the high altitude or the nival Zone.

The family Vespidae is commonly classified into three subfamilies: Stenogastrinae, Polistinae and Vespinae.

The Stenogastrinae is represented by only one genus *Stenogaster* in India. According to Van Der Vecht (1965), their restricted distribution in the Indo-Australian area is due to their specialized adaptations to the tropical rain forest.

The Polistinae is conveniently divided into 3 tribes: The Ropalidiini having one genus *Ropalidia* Guerin (=*Icaria* Saussure) of which there are 3 subgenera: (a) *Anthreneida* White, (b) *Icariella* Dalla Torre, and (c) *Paraicaria* Gribodo. The former two are found in the Oriental and Australian regions while the subgenus *Paraicaria* is not found in India but is present in other parts of the Oriental Region. The tribe Polybiini is represented in India by two genera *Belonogaster* Saussure and *Para-*

TABLE 1. The distribution of the Oriental genera of Vespidae.

Genus	Oriental (–India)	India	Palaearctic	Ethiopian	Australian	Nearctic	Neotropical
Stenogaster Guerin	+	+	—	—	+	—	—
Ropalidia (Saussure)	+	+	—	—	+	—	—
Belonogaster Saussure	—	+	+	+	—	—	—
Parapolybia Saussure	+	+	+	—	—	—	—
Polybioides Buysson	+	—	—	+	—	—	—
Polistes Latreille	+	+	+	+	+	+	+
Provespa Ashmead	+	+	—	—	—	—	—
Vespa Linnaeus	+	+	+	+	—	—	—
Paravespula Bluthgen	+	+	+	—	—	—	—
Dolichovespula Rohwer	—	+	+	—	—	—	—

TABLE 2. Distributional patterns of species of different genera in various altitudinal zones.

S. No.	Genus	I	II	III	IV	V	VI	VII
		Sea Level to 1000 m	1000m–1500m	1500m–2000m	2000m–2500m	2500m–3000m	3000m–3500m	3500m–4000m
1.	*Stenogaster*	2	1	..	..	..	..	..
2.	*Ropalidia*	25	12	4	1	..	..	..
3.	*Belonogaster*	1	..	..	..	..	..	..
4.	*Parapolybia*	2	3	1	..	..	..	..
5.	*Polistes*	13	12	10	5	4	1	1
6.	*Provespa*	..	..	2	..	..	..	..
7.	*Vespa*	20	11	5	5	3	..	..
8.	*Paravespula*	1	1	3	2	2	1	1
9.	**Dolichovespula*	..	..	..	..	1	..	1

* Reported for the first time from India.

polybia Saussure. The Polistini is represented in India by *Polistes,* the only genus of Vespidae having a world-wide distribution.

The subfamily Vespinae is restricted to the Holoarctic and Oriental areas and

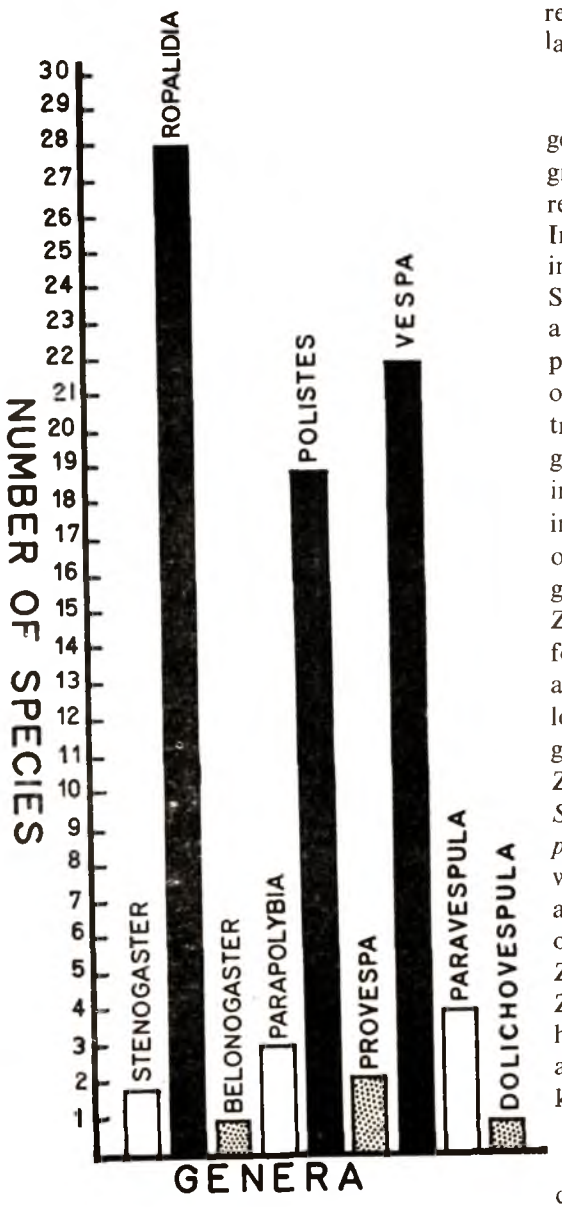


Fig. 1. Histogram showing the number of species of the various genera of Indian Vespidae.

includes 4 genea, *Provespa* Ashmead, *Vespa* Linnaeus, *Paravespula* Bluthgen and *Dolichovespula* Rohwer (Bequaert, 1930; Spradbery, 1973). Of these, the former three were previously known from India. *Dolichovespula* is a Palaearctic genus, now also reported from Ladakh, North-West Himalaya which has Palaearctic affinities.

Table 1 gives the distribution of the Indian genera in rlation to the various Zoogeographical Zones. Of the total of 10 genera reported from the Orient, 9 are present in India. The only genus which is distributed in all Zoogeographical regions is *Polistes.* So strictly Indian genera are 8, of which 5 also occur in the Palaearctic, 3 in the Ethiopian and 2 in the Australian Region. None of them is present in the Nearctic and Neotropical Regions. Fig. 1 summarizes the genera and species of Vespidae from India, including a few unnamed species present in our collection. Table 2 shows the pattern of distribution of the species of the various genera with reference to the altitudinal Zones explained above. Out of 9 genera found so far in India, *Polistes* and *Vespa* are the most abundant genera. In the lower altitudinal Zones the number of genera is more than in the higher altitudinal Zones. In Zone I, 7 genera are present *Stenogaster, Ropalidia, Belonogaster, Parapolybia, Polistes, Vespa* and *Paravespula,* while in Zone VII, only *Polistes, Paravespula* and *Dolichovespula* are present. The number of species in a genus is less in the higher Zone than that of a genus present in the lower Zone eg., higher altitude genus *Dolichovespula,* having only 1 specias, on the other hand low altitude genus *Ropalidia* having alread y 20 known species from India.

Distributional patterns of species in different genera is depicted in Fig. 2. In *Stenogaster,* only 2 species are present in India, both of which occur in the plains in

Zone I. One of them extends upto an altitude of 1,500 metres (Zone II). It appears to be a group of plains and confined to Eastern India. *Ropalidia* is distributed from Zone I to Zone IV. 25 species are located in Zone I, 12 in Zone II, 4 in Zone III and 1 specis in Zone IV. Thus they are abundant in the plains and are also found in submontane region, but their distribution above this region is very poor. The genus *Belonogaster* has only one species localised in Zone I and hence is not shown in the Figure. In *Parapolybia*, out of 3 species, 2 are distributed in Zone I and all the three species in Zone II, and only one occurring in Zone III. This genus is dominant in Zone II. The genus *Polistes* is distributed in all the Zones. The maximum number of species is present in Zone I. The number of species diminishes gradually with the increase in altitude. One of the Indian species, *Polistes maculipennis,* is found from sea level up to an high altitude of 3900 metres in Ladakh region in Zone VII. The genus *Provespa* has only two species restricted in Zone III. This genus is reported only from Sikkim. It is not shown in the figure. The distribution of the genus *Vespa* extends from Zone I

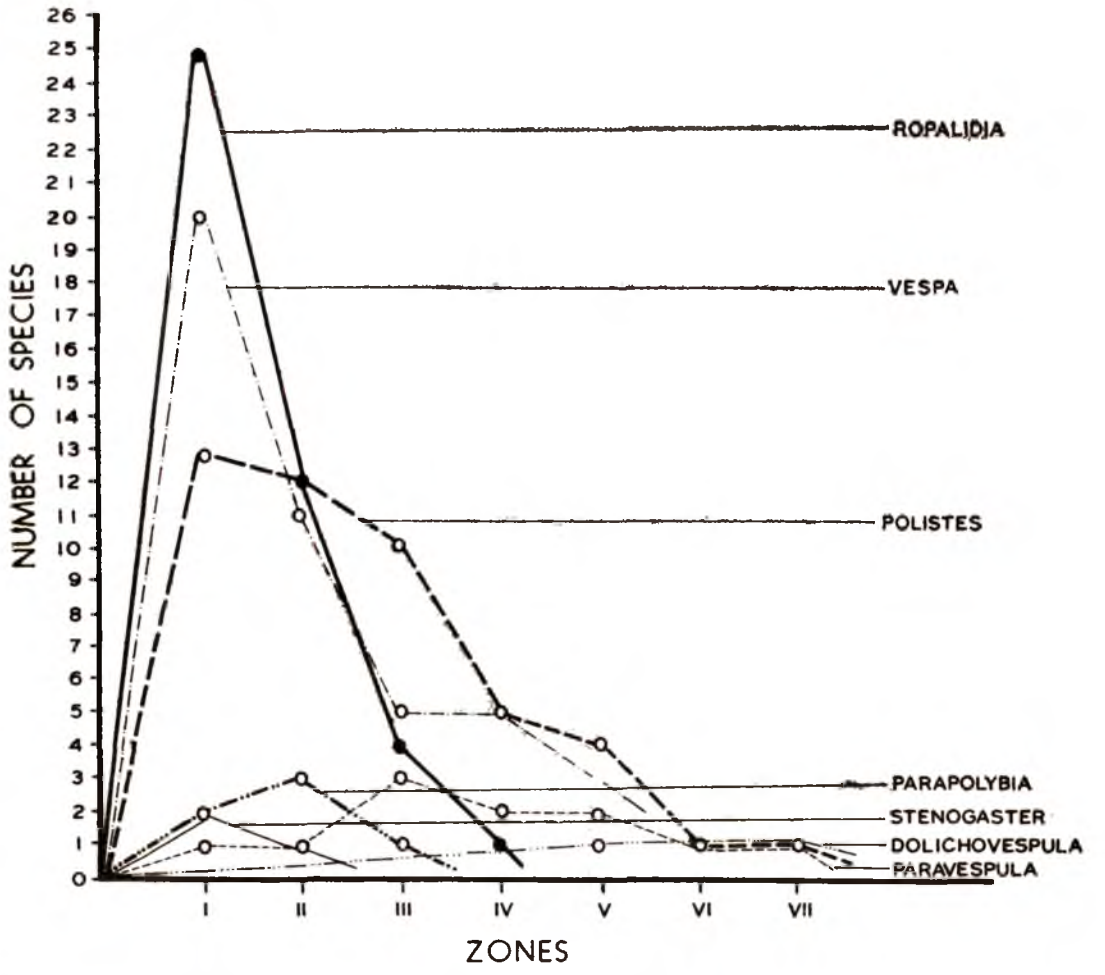


Fig. 2. Distributional patterns of species of Indian Vespidae in relation to altitudinal zones I–VII.

to Zone V. The maximum number of species is confined to Zone I. The number of species diminished with the increase of altitude. The genus *Paravespula* is distributed in all the Zones. The maximum number of species are confined to Zone III. The number of species diminished on both the direction. One species which appears to be new one, is reported for the first time from Ladakh range, and is not found in the lower Zones. *Dolichovespula* is a small genus with only 1 species and not previously known from India. This genus is localised in Zone V to VII. These insects are not found in the lower Zones. Thus they appear to be high altitude insects, restricted to higher alpine and nival Zones.

CONCLUSION

Out of the 30 genera known so far in the world only 9 are reported from India and 10 genera in the Oriental Region. In India, the genus *Ropalidia* (Saussure) has the maximum number of species. An analysis of the distributional patterns of Vespidae shows that they are most abundant in Zone I, Zone II and in Zone III. Of the 9 genera found so far in India, *Vespa* Linnaeus and *Polistes* Latreille are the most abundant genera. The genus *Polistes* is widely distributed throughout the world. One of the Indian species, *Polistes maculipennis* Sauss., is found from sea level to an altitude of 3,900 metres in Ladakh in the Himalaya. The number of species in a genus is less in the higher Zone than that of a genus present in the lower Zone, eg. higher altitude genus *Dolichovespula* having only 1 species, on the other hand low altitude genus *Ropalidia* having already 20 known species from India. The genus *Polybioides* Buysson is reported from Oriental Region but is not found in India, whereas *Dolichovespula* Rohwer is reported for the first time from Ladakh Range, North West Himalaya, and is not so far been discovered in the rest of India. This is a Palaearctic genus and thus the present study confirms the Palaearctic affinities of Ladakh.

Acknowledgements:- We are thankful to the Head of the Department of Zoology, University of Delhi, for laboratory facilities and for the award of a CAS Research Fellowship to one of the authors (Bina Pani Das). We are also thankful to Prof. Dr. J. van der Vecht, Burg. Vermeerlaan 4 Putten (Gld), Netherlands, for helpful comments on the identity of some species.

REFERENCES

BEQUAERT, J. (1930) On the generic and subgeneric divisions of Vespinae. *Bull. Brooklyn ent. Soc.*, **25** (2) : 55–70.

BINGHAM, C. T. (1897) *Bees and Wasps. Fauna of British India, Hymenoptera.* **1** : 375–407.

LIU, C. L. (1936–37) A bibliographic and synonymic catalogue of the Vespidae of China, with a cross-referring index for the genera and species. *Peking nat. Hist. Bull.*, **11** (3) : 205–232.

SPRADBERY, J. PHILIP (1973) *Wasps. An account of the Biology and Natural History of Solitary and Social Wasps.* Sidgwick & Jackson, London. 408pp.

VECHT, J. VAN DER (1941) The Indo-Australian species of the genus *Ropalidia* (*Icaria*) (Hymenoptera : Vespidae) (First paper). *Treubia*, **18** : 103–190.

VECHT, J. VAN DER (1957) The Vespinae of the Indo-Malayan and Papuan areas (Hymenoptera : Vespidae). *Zool. Verh.*, **34** : 1–83.

VECHT, J. VAN DER (1959) Notes on Oriental Vespinae including some species from China and Japan (Hymenoptera : Vespidae). *Zool. Meded. Leiden*, **36** (13) : 205–232.

VECHT, J. VAN DER (1962) The Indo-Australian species of the genus *Ropalidia* (*Icaria*) (Hymenoptera : Vespidae) (Second paper). *Rijksmus. Nat. Hist. Leiden*, **57** : 3–17.

VECHT, J. VAN DER (1965) The geographical distribution of the social wasps (Hymenoptera, Vespidae). *Proc. 12th Int. Congr. Ent.* London, 1964 : 440–441.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 215 *to* 219

SOUTH INDIAN PROTURA. IV. TWO NEW SPECIES

N. R. PRABHOO
Department of Zoology, University of Kerala, Kariavattom,
India 695581

(*Received 27 May 1977*)

***Eosentomon nayari* sp. nov. and *Brasilidia nagaroorica* sp. nov. are described from soils of a thicket and forests in Kerala. The genus *Brasilidia* is described for the first time from India.**

The present paper is based on a small collection of Protura from the soils of a thicket at Nagaroor and forests at Arippa and Ponmudi, the latter regions forming the foot hills of the Western ghats in Kerala. The holotypes of the two new species described below will be deposited in the National collection with the Zoological Survey of India, Calcutta. With the present contribution the total number of species of Protura reported from India would come to 15, all of which come from Kerala only.

1. Eosentomon nayari sp. nov. (Figs. 1–4)

Body 970μ to 1020 μ long. Head 98μ to 102μ. Pseudoculus small, without globules. PR = 10. Labrum minute. Labral setae present. Mouth parts normal, somewhat protruding in profile. Clypeal apodeme with a narrow anterior bar.

Foretarsus excluding the claw 77 μ to 80μ. Claw I, 16 μ to 16.5 μ; TR = 4.8; EU = 0.9; BS = 1.1; t_1 small and of normal shape $\alpha 3'$ arising distinctly anterior to t_1 and almost on a level with $\alpha 4$; *d* longer than t_2; t_3 long and slender; *a* and *b* well developed; *c* short; f_1, *y* and *z* slender; f_2 absent; *e* and *g* spatulate. On the inner side a' is large; b_1' and b_2' absent; c' short. Empodium on the middle and hind legs rudimentary. Spine on the hindleg fairly developed.

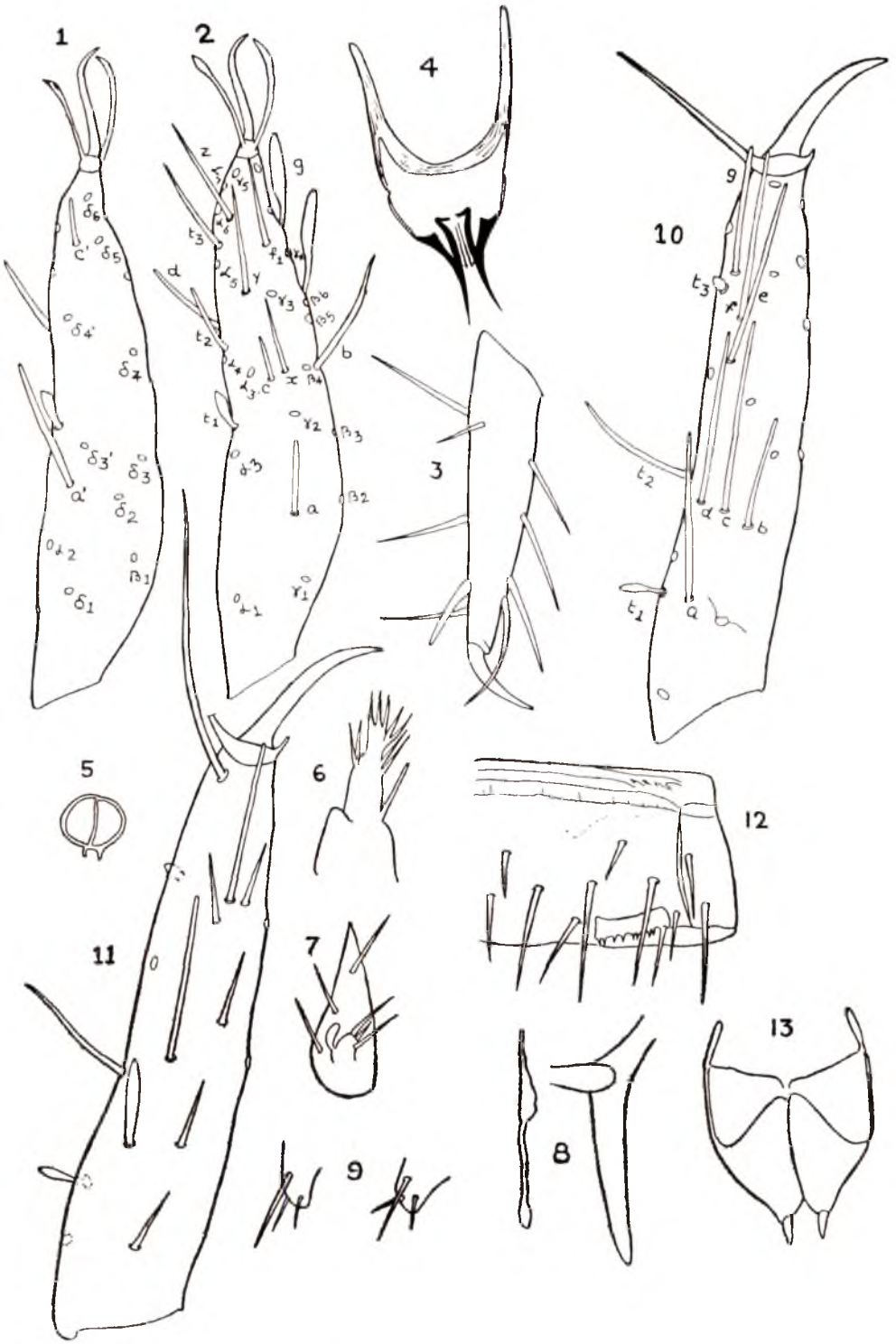
Central lobe of the praecosta VII is clearly incised. Chaetotaxy of thoracic and abdominal segments as given in Table 1.

Accessory setae on abdominal tergites I—VII generally arise a little behind the principal setae. P1a on tergites I—VI on a level with other accessory setae, but on tergite VII it arises a little closer to and on a level with P2. The accessory setae are almost equal in length to the principal setae so that the former appear to bypass the latter.

Squama genitalis of the female of the "*maya*" type (Tuxen, 1964) with the caput processus 'dissolved'; corpus processus sharply bent against the median edge of the stylus nearly at right angles.

Holotype : ♀ on slide, INDIA : KERALA : Trivandrum district, Nagaroor, ca. 100 m, soil from thicket, 9. ix. 1974, coll. N.R. Prabhoo. **Paratypes:** 2 ♀ ♀ on slides, data as above; ♀ and ♂ on slide, Ponmudi, ca. 300 m 28.iii.1975, from soil of a mixed evergreen forest, coll. N.R. Prabhoo.

The new species described above is closely related to *Eosentomon pusillum* Ewing from Florida (U.S.A.) redescribed by Tuxen (1964). The female squama is almost similar to that figured by Tuxen (1976, Fig. 19 E, p 463). The new species is distinguishable from *E. pusillum* by narrow anterior bar of the clypeal apodeme, absence of the



Figs. 1 — 4. *Eosentomon nayari* sp. nov., female : 1. tarsus I inner side; 2. tarsus I outer side; 3. hindleg; 4. female squama. Figs. 5 — 13. *Brasilidia nagaroorica* sp. nov., female: 5. pseudoculus; 6. maxillary palp; 7. labial palp; 8. filamento; 9. abdominal legs II–III; 10. tarsus I, inner side; 11. tarsus I outer side; 12. right half of abdominal tergite VIII; 13. female squama.

TABLE 1. Body chaetotaxy of *Eosentomon nayari*.

		Thoracic segments			Abdominal segments										
		I	II	III	I	II-III	IV	V	VI	VII	VIII	IX	X	XI	XII
T		4	6	6	4	10	10	8	6	4	6	8	8	4	6
			16	16	10	16	16	16	16	16	9				3
S		6–2	6–2	6–4	4	6	6	6	6	6	0	4	4	8	8
		6	6	8	4	10	4	10	10	10	7				4

Roman numerals indicate the segment numbers. T—tergites; S—sternites.

sensillae f_2, b_1' and b_2' and the presence of c' on the foretarsus. A significant difference in the chaetotaxy is the absence of the two anterior setae on the sternite VIII of the abodomen of the new species and their presence in *E. pusillum*. *E. nayari* also shows some resemblance to *E. paktai* Imadate (1965) from Thailand in the nature of the female squama but in the latter species there is a considerable reduction in the anterior row of setae on abdominal tergites IV—VII, apart from the presence of the sensillae f_2 and b_2'.

This new species is named in honour of my teacher, the late Professor K. K. Nayar.

2. Brasilidia nagaroorica sp.nov. (Figs. 5–13)

Body upto 1092μ long when fully expanded. Head upto 105μ . Pseudoculi divided with a short lever. PR = 16. Labrum minute. LR=19. Labial and maxillary palps normal. Filamento with the proximal part two thirds of the proximal branch of the fulcrum and provided with a swelling at the end. Calyx rather narrow, only slightly broader than the proximal swelling.

Tarsus I up to 84μ. Claw I up to 24μ. TR = 3.5 to 3.6; EU=0.15; BS=0.34; sensillae *a* to *g* on the outer side related as 30 : 20 : 35 : 30 : 34 : 30 : 21 ; *b* is the smallest sensilla. On the inner side *a'* is broad, *b'* and *c'* subequal and narrow. t_1 claviform with almost parallel sides; t_2 normal and t_3 short and bud like being as long as broad and different from the normal type in *Brasilidia* and *Australentulus*. Similarly the sensillae *b* and *c* are not situated markedly behind *d* as is normal for *Australentulus* and *Brasilidia*.

Chaetotaxy of thoracic and abdominal segments as given in Table 2. Comb VIII with about eight small dispersed teeth.

Striate band with a few weak striae. Squama genitalis of the female with well developed acrostylus.

Holotype : ♀ on slide and **allotype** : ♂ on slide, INDIA : KERALA : Trivandrum district, Nagaroor, from soil of a thicket, ca. 100 m, 9.ix.1974, coll. N.R. Prabhoo. **Paratypes** 4 ♀♀ on slides and other examples 12 ♀♀ and 3 ♂♂ on slides, other data as that for holotype. ♀ on slide, Arippa pacha, ca. 200 m, from soil of a mixed evergreen forest, coll. N. R. Prabhoo.

The genus *Brasilidia* was created for accommodating the species *Brasilidia tropica* from Brazil, by Nosek (1973). Tuxen (1976) redescribed this genus and gave a new diagnosis. The genus is closely related to *Australentulus* but is distinguished from it mainly by the striate band on abdominal tergite VIII which is provided with weakly developed and few complete striae in *Brasilidia* in contrast to the numerous complete striae in *Australentulus*. Besides this, Tuxen (1976) also mentions the presence of two posterior setae on sternite VIII in *Brasilidia* as a character distinguishing this genus from *Australentulus*. In the new species described above the striate band on tergite VIII is weakly developed which character has led to its being kept under *Brasilidia*. But the posterior two setae are missing in the sternite VIII of the abdomen which makes it different from *Brasilidia*. Further the sensilla t_3 is quite unlike that of both *Australentulus* and *Brasilidia*. Yet another character of importance is the position of the sensilla *d* which is generally shifted distally from the level of *b* and *c* in *Austrlaentulus* and *Brasilidia*, a feature not found in the present species as mentioned above. Based on the nature of t_3 and the lack of posterior setae on sternite VIII a new genus may have to be created for the accommodation of the new species described above. This is how-

TABLE 2. Body chaetotaxy of *Brasilidia nagarooorica*.

	Thoracic segments			Abdominal segments											
	I	II	III	I	II–III	IV	V	VI	VII	VIII	IX	X	XI	XII
T	4	6	6	6	8	8	8	8	6	6–8	14	12	6	9
		14	14	12	14	14	14	16	16	8				
S	4–2	7–2	7–2	3	3	3	3	3	3	4	4	4	6	6
	6	4	4	5	8	8	8	8	8					

Roman numbers indicate the segment numbers. T—tergites; S—sternites.

ever not desirable at this stage when only two species are known under *Brasilidia*.

Acknowledgement:– I wish to thank Prof. K. M. Alexander for facilities in the Department.

REFERENCES

IMADATE, G. (1965) Proturans-fauna of South east Asia. *Nature & Life in Southeast Asia*, **4** : 195–302.

NOSEK, J. (1974) Five new species of Protura from Brazil. *Vestnik csl. Spol. zool.*, **37** : 27–36.

TUXEN, S. L. (1964) *The Protura. A Revision of the Species of the World*. Hermann, Paris, 360 pp.

TUXEN, S. L. (1976) The Protura (Insecta) of Brazil, especially Amazonas. *Amazoniana*, **5**: 417–463.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 221 *to* 223

A NEW SPECIES, *PROCIPHILUS CORNIFOLIAE* (HOMOPTERA : APHIDIDAE) FROM NEPAL AND MANIPUR (INDIA)

T. K. SINGH, B. C. DAS[1] & D. N. RAYCHAUDHURI
Entomology Laboratory, Department of Zoology, Calcutta University, Calcutta, India

(*Received 15 June 1977*)

A new species of the genus *Prociphilus* is described from Nepal and Manipur (India).

The first and second authors collected the material during their recent survey of Manipur and Nepal independently. After careful study it was found that both are the same and this happens to be new to science.

Prociphilus cornifoliae, sp. nov.

Apterous viviparous female (Fig. 1) :

Body oblong, about 4.19 mm long with 3.05 mm as the maximum width. Head pale brown, without lateral frontal tubercles, with complete median suture, with large two pairs of hair-bearing wax-plates; each wax-plate with numerous compact hexagonal cells; dorsal cephalic hairs excepting those on wax-plates rather long and fine, longest one about 1.30 × basal diameter of antennal segment III, those on wax-plates about 0.66 × the mentioned diameter. Antennae concolourous with head excepting the basal segments, the distal 0.5 portion of segment III, whole of segments IV and V which are slightly more darker, 5 segmented, about 0.30 × the body; segment I as long as wide and segment II much longer than wide; flagellum with spinular imbrications excepting on the basal 0.5 portion of segment III which slightly scabrous; hairs on flagellum sparse, long with fine apices, longest hair on the atennal segment III about 1.33 × the mentioned diameter; base of segment V with 4 long fine hairs; p.t. about 0.20 × the base of antennal segment V, with 5 short spine-like hairs; primary rhinaria ciliated. Eyes 3-faceted. Rostrum nearly reaches midcoxae; u.r.s. about 0.73 × h.t.2, with 3 secondary hairs and with the surface roughened with small pimples (? wax-pores). Thoracic tergites pale and also with wax plates as on the dorsum of head. Abdominal dorsum pale, each of abdominal segments 2–7 with a pair of hair-bearing wax-plates marginally, the plates gradually become larger caudad and so also the cells, similar wax-plates present pleurally on each of segments 7 and 8; dorsal hairs on anterior tergites long and fine, longest one being about 1.46 × basal diameter of antennal segment III; 8th tergite with 2 spinal hairs; the longest one being about 1.21 × the mentioned diameter; spiracular plates brown. Siphunculi absent. Cauda semioval with 6 hairs. Legs brown excepting near the apices of femora and base of tibiae which are more dark; trochanter imperfectly fused with coxa; femora and tibiae smooth but with small pimples (? wax-pores) on surfaces; hairs on legs fine: empodial hairs stripe-like and stout, nearly as long as claws; the dorso-apical hairs on second tarsal segment with fine apices. F.T.C. 2,2,2.

[1] Present address : Zoological Survey of India, Calcutta-12.

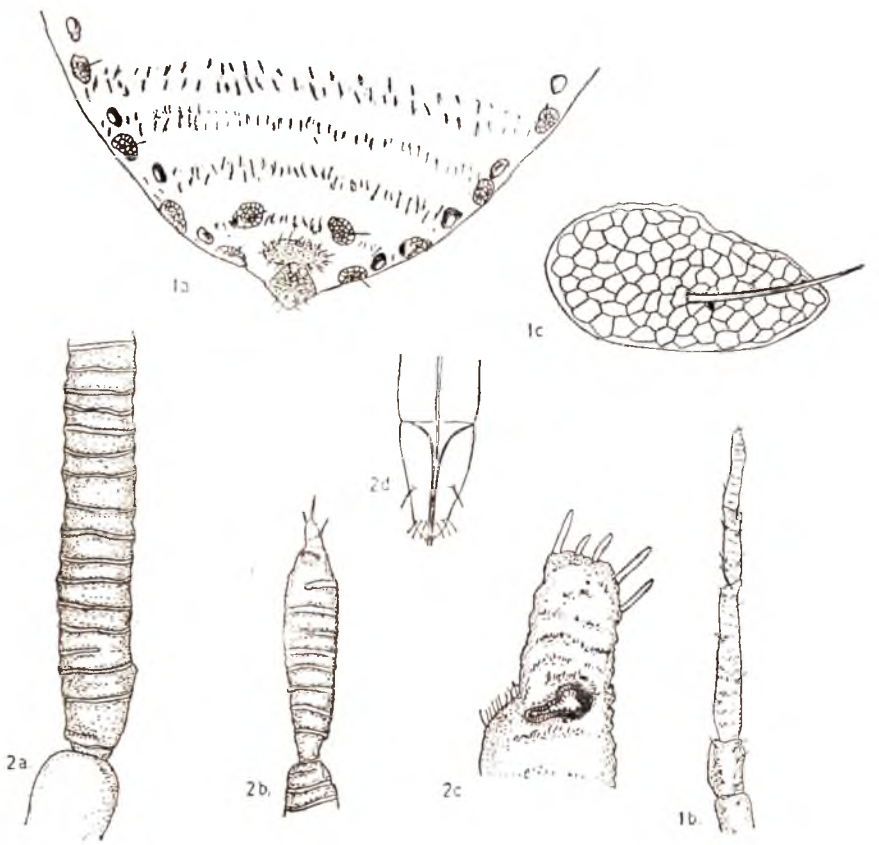


Fig. 1. *Prociphilus cornifoliae* sp. nov. apterous viviparous female. 1a. Posterior part of abdomen; 1b. antenna; 1c. wax plate; Fig. 2. *P. cornifoliae* Sp. nov. alate viviparous female; 2a. Part of antennal segment III; 2b. Antennal segment VI; 2c. Processus terminalis; 2d. Ultimate rostral segment.

Measurement of the holotype in mm: Length of body 4.19; width of body 3.05; antenna 3.05; antennal segmets III:IV:V 0.47:0.21: (0.21+0.04); u.r.s. 0.14; h.t. 2 0.19.

Alate viviparous female (Fig. 2):

Body about 2.90–3.47 mm long with about 1.51–1.73 mm as maximum width. Head dark brown, with minute wax-pores and pitted hair bases and a pair of hair-bearing wax-plates spinally on posterior margin; dorsal cephalic hairs long and fine, longest hair about 2.44 × basal diameter of antennal segment III. Antennae 6-segmented, brown, about 0.47—0.52 × the body; basal two segments with minute wax-pores; flagellum with fine spinulose imbrications, each of segments III, IV, V and base of segment VI with ciliated subannular secondary rhinaria, segment III with 31–33, IV with 13, V with 15 and VI with 7–9 such rhinaria; p.t. short, about 0.20–0.30 × base of antennal segment VI, with 5 spiny hairs at the apices. Rostrum not reaching mid-coxae, u.r.s. about 0.61—0.64 × h.t.2 with 2 secondary hairs. Mesothoracic lobes dark brown, pitted at hair-bases and with cribriform wax pores. Abdominal dorsum pale, wih marginal hair-bearing wax-plates having heavily chitinized rim; segment

8 with similar wax-plate spinally; dorsal hairs short and sparse, longest hair on the anterior tergites about 0.80—1.11 × the mentioned diameter. Sipunculi absent. Cauda semioval and brown. Legs dark brown. Media of forewing simple, cubitus and anal veins in the forewing not united at the base; hindwing with two oblique veins. F.T.C. 2,2,2. Measurement of a morphotype in mm: Length of body 2.90; width of body 1.51; antenna 1.51; antennal segments III:IV:V:VI 0.55:0.25:0.27: (0.22+ 0.15); u.r.s. 0.14; h.t. 2 0.22.

Holotype, 1 apterous viviparous ♀ ; INDIA: MANIPUR: Mao (ca. 2103.48 m) from *Cornus* sp. (Cornaceae), 15. iv. 1974, coll. T.K. Singh.

Morphotype: 5 alate viviparous ♀ ♀ and 6 nymphs, NEPAL, Balaju (ca. 1400 m) from an unidentified plant, 14.iv.1975, coll. B.C. Das; 2 alate viviparous ♀ ♀ and 7 nymphs with same data as holotype. At present, type material are deposited in the Entomology Lab., Depart. of Zoology, C.U.

The new species comes close to *P. cheni* Tao by linear primary rhinaria of antennal segment V and circular rhinaria of segment VI, number and nature of secondary rhinaria, body pigmentation and frontal suture in alate viviparae but differs in the following characters: u.r.s. much shorter (about 0.58 × h.t.2, in *P. cheni* about 0.73 × h.t.2), Rs. in the forewing bordered brown and base of antennal segment VI with 7–9 secondary rhinaria (in *P. cheni* secondary rhinaria absent on base of antennal segment VI), secondary hairs on u.r.s. 2–3 (in *P. cheni* more than 8).

Acknowledgements:– The authors are thankful to the Head of the Department of Zoology for providing laboratory facilities and to Dr. C. C. C. Tao, Taiwan for kindly sending the slides of *P. cheni* Tao for comparison. One of the authors Mr. Das is thankful to the joint Director in-charge, Zoological Survey of India, Calcutta for he kind permission given to pursue the work in the Entomology Laboratory, Department of Zoology, University of Calcutta.

REFERENCES

TAO, C. C. C. (1970) Revision of Chinese Eriosomatinae, Aphididae, Homoptera. *Q. J. Taiwan. Mus.*, **23** (3–4) : 135–149.

Entomon, 1977, *Vol.* **2**, *No.* 2, *pp.* 225 *to* 230

LAST INSTAR LARVAE OF TWO ODONATA SPECIES FROM WESTERN HIMALAYAS

ARUN KUMAR & M. PRASAD
Northern Regional Station, Zoological Survey of India, Dehra Dun, India 248001

(*Received 17 January 1977*)

Last instar larvae of *Calicnemia miles* Laidlaw (Family Platycnemididae) and *Anisopleura lestoides* (Selys) (Family Epallagidae) are described and illustrated on the basis of materials from the Dehradun Valley, U. P. The former lives in semiterrestrial habitat among wet mosses and ferns and the latter in semipermanent hill streams. Larvae of *C. miles* show very close resemblance to the terrestrial *Megapodagrionidea* larvae, while the larvae of *A. lestoides* are characterized by the presence of paired abdominal appendages on segments 2—8.

Odonata larvae occur in different types of aquatic habitats—be they permanent or temporary. However. larvae of certain species show very interesting structural development in relation to peculiar habitat in which they are found. In the present paper descriptions and illustrations are given herewith of two such interesting forms of larvae, *viz., Calicnemia miles* Laid. and *Anisopleura lestoides* (Selys).

Larvae of *C. miles* occur in peculiar semiterrestrial habitat among thick carpet like growth of wet mosses and ferns which invariably grow on almost vertical slopes of hills near water falls; sprinkling water seeps through this vegetation. The larvae show characterstic adaptations in its squat compact form, dense body covering of setae and saccoid caudal lamellae.

Larvae of *A. lestoides* are litho-rheobiont and are found in semi-permanent hill streams which are characterized by stony bed and sparse vegetation. They are found concealed below small stones some times in company of another epallagid, *Bayadera indica* (Selys). Larvae of *A. lestoides* are peculiar in having paired abdominal appendages on segments 2–8; which are characteristic feature of larvae of the family Epallagidae (Kumar, 1973).

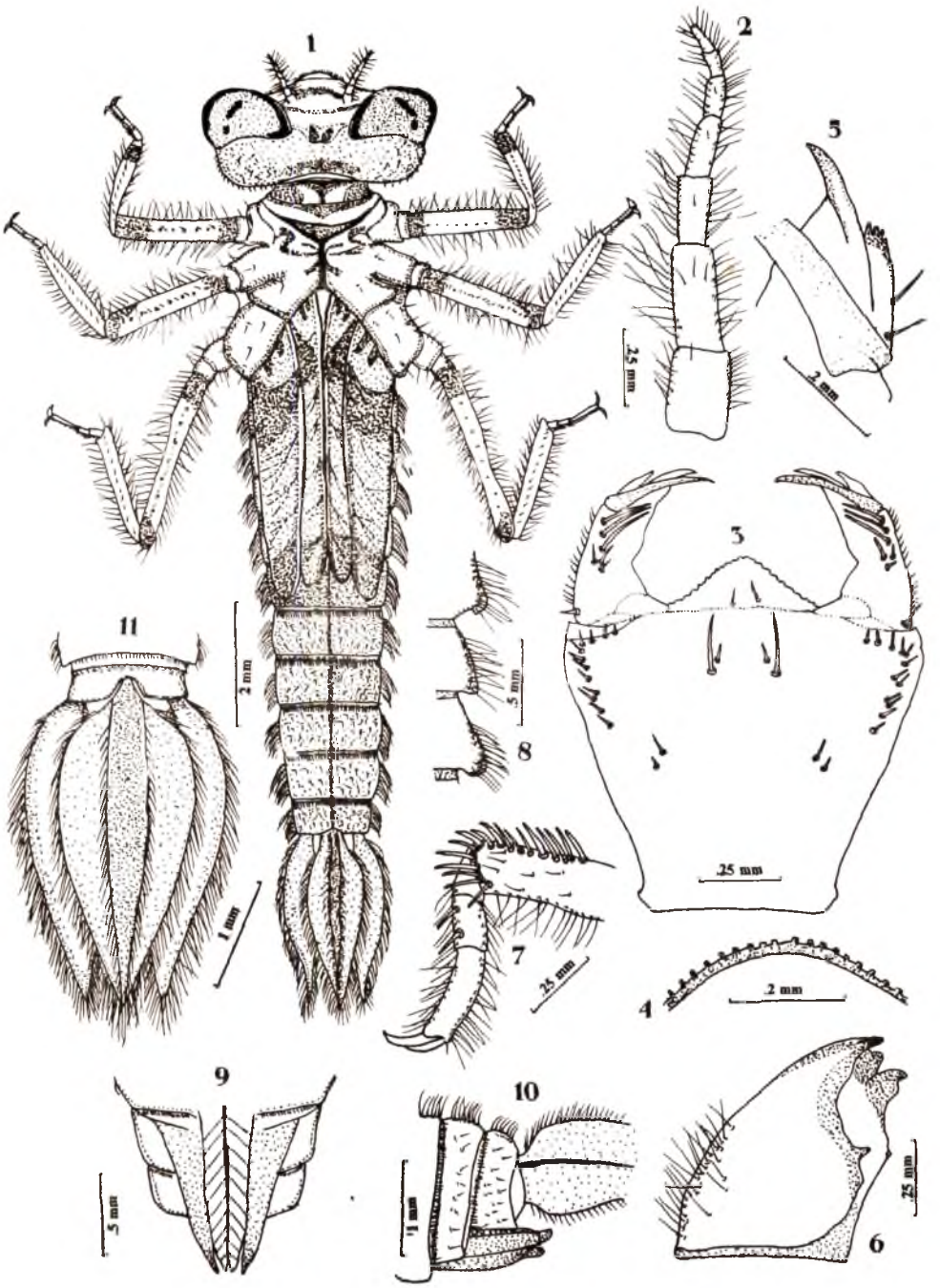
In the present paper detailed descriptions of two morphologically peculiar last instar larvae occurring in two atypical aquatic habitats have been given. Work of Fraser (1933, 1934) was consulted for indentification of the species and for their general distribution.

1. **Calicnemia miles** Laidlaw (Figs. 1–11)

Squat, compact larvae with dense covering and saccoid caudal lamellae; adbomen with thick lateral bunches of setae. Length 15.22 mm, excluding antennae (varying from 15.0 to 17.1 mm); width 3.83 mm, maximum across the eyes.

Colour : Palish to dirty brown, dark on head and wing buds; faint markings on femur of all three pairs of legs.

Antennae (Fig. 2) : thick, hairy, beset with dense setae on all the segments; filiform. Measurements (in mm) of segments, 0.27, 0.34, 0.22, 0.20, 0.12, 0.09 and 0.10; total length 1.34 mm. Labium (Figs 3–5):



Figs. 1—11. *Calicnemia miles* Laidlaw. 1-larva; 2-antenna; 3-labium (oral view); 4-enlarged view distal margin prementum; 5-enlarged view distal margin palpus; 6-mandible; 7-tibial comb and tarsi; 8-enlarged view lateral margin terminal abdominal segments; 9-female gonapophyses; 10-female gonapophyses (lateral view); 11- caudal lamellae.

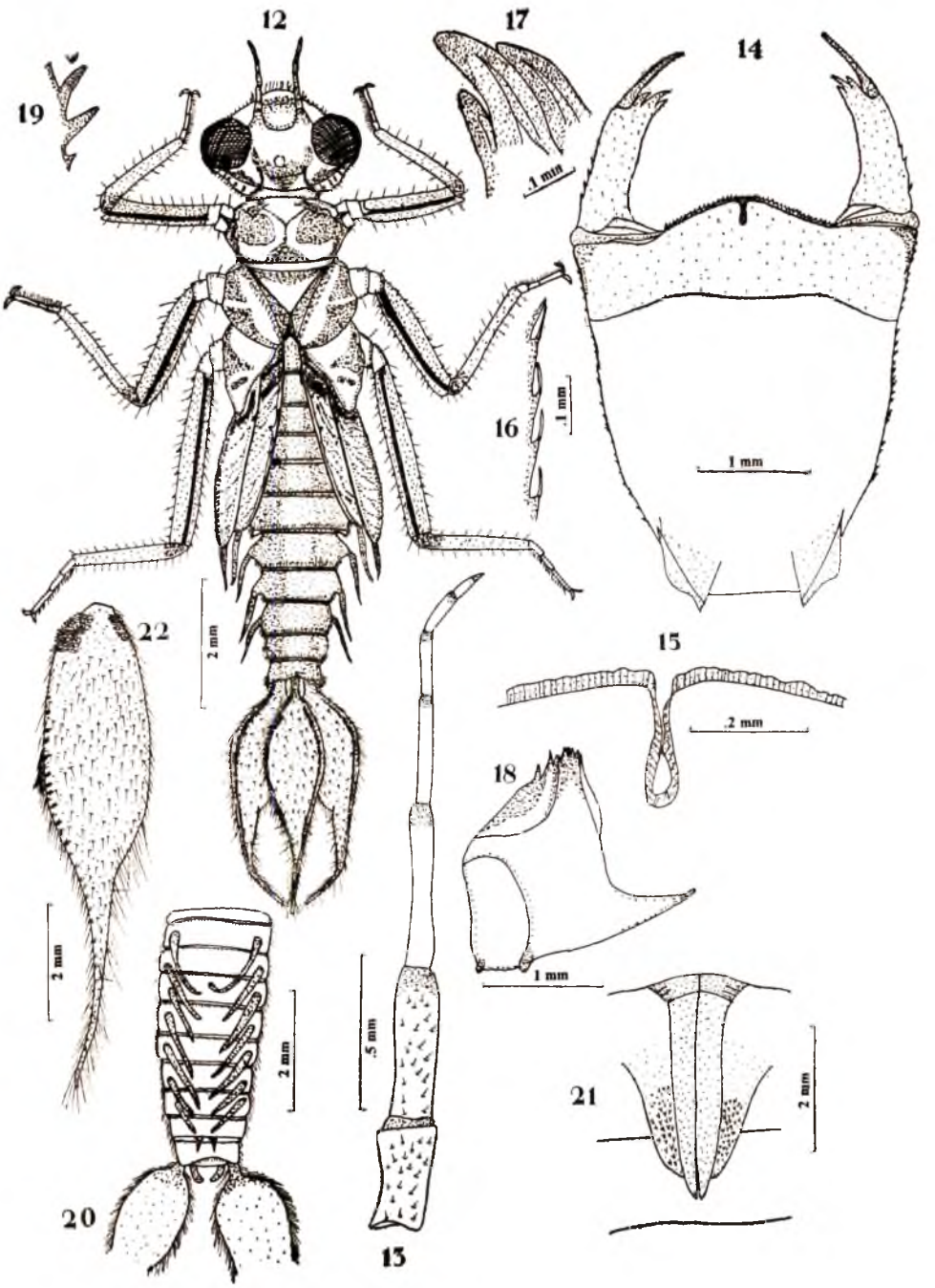
thick, compact; premental setae $^{1}1 + 1^{1}$, a number of lateral spiniform setae present in distal half and below the base of palpus; two setella each present mesolaterally in proximal half of prementum, distal margin or prementum strongly convex, subspherical with pectinate margin (Figs. 3 & 4). Palpal setae $^{3}3 + 3^{3}$, arranged closely; one spiniform seta each present laterally at base of palpus; laterally beset with thickly arranged simple setae, distal margin of palpus formed into two lobes by a deep cleft, inner one curved hook like, outer blunt formed into three teeth (Fig. 5). Movable hook medium sized. Mandible (Fig. 6) with three well formed blunt teeth. Tibial comb and tarsi (Fig. 7): tibial comb comprises a number of closely arranged spiniform setae; tarsi generally beset with simple setae. Tibiae short, thick and a bit bowed. Legs thickly hairy-all the segments beset with long dense setae. Abdomen: almost cylindrical, segments faintly annulated; narrowing distally, densely hairy. Bunch of thick lateral setae present on segments (Figs. 7 & 8), these give the larvae characteristic hairy appearance like those of the Family Megapodagrionidae (Willey, 1955); Gonapophyses (Figs. 9 & 10): in male, paired bluntly traingular processes situated at distal margin of 9th segment and extend upto anterior half of 10th segment; in female paired processes arising from the base of 9th segment and extending well distal to 10th segment. Caudal lamellae (Figs. 1 & 11): saccoid, hairy and almost napiform in shape; epiproct: length 2.80 mm tapering both proximally and distally, thickly beset with setae, a median band with a marginal row of setae present; paraprocts length 2.85 mm; similar to epiproct.

Biology: Larvae occur in very characteristic semiterrestrial habitat of damp thick carpet like growth of mosses and ferns which grow near water falls on vertical hill rocks. The spring water either seeps through it or regularly sprinkle on it from these falls. Emergence occurs in early summer and a number of pairs are observed soon after ovipositing in tandem.

Material : INDIA : U. P. : Dehradun, Sulphur Springs, 17. vii. 1976, 1 larva (♂) emerged on 12. vii. 1976, M. Prasad Coll; Sulphur Springs, 9. vii. 1976, 6 larvae (2♂♂; 4♀♀) in different instars, A. Kumar & M. Prasad Coll.

Distribution: India: U.P.: Chamoli, Dehra Dun, Pauri, Tehri; Uttarkashi, Almora; H. P. Kangra; Sikkim; Upper Burma.

Larva of *C. miles* Laid. show very diverging differences in its morphological characters and habits from those of the other two known larvae of genus *Calicnemia,* i. e., *C. miniata* Selys (Fraser, 1919) and an unidentified species (Laidlaw, 1917); both recorded as stream breeding forms from Eastern Himalaya. Lieftinck (1958) in his tentative key to the larvae of Platycnemididae has diagnosed the genus *Calicnemia* on the basis of following characters "premental setae 4+4 placed in very oblique rows rather far back; i. e., about mid-way the length of prementum. Palpal setae 7+7; no short spiniform setae along exterior margin. Abdominal segment with lateral carinae drawn out to apical sharp points (Known only from incomplete description and poor illustrations)". The presently described larvae of *g. miles* does not show affinity with the above descriptions. However, the larva in its peculiar habits and external appearance show very close resemblance to some semiterrestrial and terrestrial larvae of family Megapodagrionidae occurring in Hawaii and New Caledonia (Williams, 1936; Willey, 1955; Lieftinck, 1956 and Corbet, 1962, in inhabiting the damp mosses and ferns and in having squat compact form, dense covering of setae and saccoid caudal lamellae. Lieftinck (1956) while discussing



Figs. 12–22. *Anisopleura lestoides* (Selys). 12–larva; 13–antenna; 14–labium (oral view); 15–enlarged view prementum; 16–enlarged view lateral margin prementum; 17–enlarged view distal margin palpus; 18–mandible; 19–ocular spines (ventral view); 20–paired abdominal appendages (ventral view); 21–female gonapophyses; 22–epiproct.

about some of these transitional larval forms justifiably pointed out that their morphological peculiarities are adaptations correlated to their habits rather than evolutionary characters; this view seems to be further strengthened by such close morphological resemblance in two widely different groups of larvae (i.e., *C. miles* and genus *Megalagrion*) but inhabiting the same type of habitat, while the larvae of *C. miles* and *C. miniata* are widely different morphologically since they are found in different types of aquatic habitats.

2. Anisopleura lestoides (Selys) (Figs. 12–22)

Naked, elongated and slim larvae with paired abdominal appendages on segments II–VIII. Caudal lamellae saccoid, apically ending into large narrow processes. Length 24.1 mm, excluding antennae (varying from 22.3 to 26.8 mm; width 4.7 mm, maximum across the eyes. Colour: sienna to black, darker on head and wing buds. Antennae: (Fig. 13) thick, bare, filiform; measurements (in mm) of segments 0.34, 0.53, 0.54, 0.35, 0.21, 0.14, and 0.12; total length 2.23 mm. Labium (Figs. 14–17)—thick, almost rectangular, no major premental and palpal setae present. Distal margin of prementum convex, weakly chitinised, serrated, with a median furrow; laterally spinate, each process beset with a seta. Distal end of palpus ends into three finger like processes (Fig. 17), a few lateral serrations present in proximal half. Movable hook medium sized. Mandible (Fig. 18)—with teeth in two groups. Ocular spines (Fig. 19) 2 in number. Tibia comb and tarsi: tibial comb comprises a number of thick simple setae and a few pectinate setae; tarsi also beset with thick, simple and pectinate setae. Abdomen: cylindrical, annulated, gently tapering posteriorly; paired abdominal appendages present on segments II–VIII (Fig. 20), these are roughly S shaped and remain spread laterally in living condition, greyish with pointed tips and a median trachea with lateral branches which run obliquely downwards; beset with a row of setae. Gonapophyses (Figs. 20 & 21)—in male small, paired triangular structures arising from the distal end of segment IX and extending upto anterior half of segment X; in female it arises from the base of segment IX and extends upto the posterior half of segment X; cylindrical, beset with a number of spinate processes. Caudal lamellae (Figs. 12 & 22): epiproct and paraprocts in the form of fusiform, saccoid, caudal lamellae ending into long, narrow processes apically; thickly beset with setae, slightly paler than body. Epiproct: length 6.92 mm; paraprocts–length 7.41 mm.

Biology: Larvae are litho-rheobiont and occur in small hill streams. These are characterized by rapid currents, clear water and stony beds. These larvae have habits almost identical to those of *Bayadera indica* (Selys), some times larvae of both the species are found together in the same area of a stream.

Larvae remain concealed in crevices among small stones and pebbles in shallow water of these streams.

Emergence of adults from these streams occurs in summer (in May-June) before the advent of the monsoon. During the period flow of water in these streams is minimum. Mature larvae move into shallow water near the bank and for emergence they crawl above water line on partially submerged boulders. Soon after the emergence the adults move to neighbouring forest and sheltered sites; these adults do not frequent the streams till the decline of the following monsoon when the oviposition takes place. Oviposition takes place in tandem in submerged vegetation at the bank of these streams.

Fraser (1928, 1957) recorded the absence of paired andominal gills in the larvae of genus *Anisopleura* (sub. *A. subplatystyla*

Fraser) and probably also in *Bayadera* and *Epallage*. On the basis of the above character he (1928) wanted to retain only the above 3 genera in Epallaginae while the genus *Pseudopheae* and *Indopheae* (larvae with paired abdominal gills) he proposed (l.c.) to group into a separate sub-faimily Psudophiinae. However, his above deduction was incorrect since the presence of paired abdominal gills in the larvae of *Anisopleura comes* was reported by Needham (1911) in *Epallage fatime* by Popova (1953), and in *Bayadera indica* by Kumar (1973). Further, Lieftinck (1962) deduced that these larval paired abdominal gills are present in all the members of the family Polythoridae (Neotropical) and Epallagidae (chiefly Oriental).

Larvae of *A. lestoides* and *B. indica* are morphologically very close and are generally found together in the streams. However, the larvae of the two species can be separated on the basis of following characters: 1. larvae of *B. indica* are larger in size (varying from 29.1 to 31.0 mm); 2. distal half of labium of *A. lestoides* is distinctly darker, while in *B. indica* labium is of uniform colouration; 3. caudal lamellae in *A. lestoides* are longer and narrower apically than of *B. indica;* 4. larvae of *A. lestoides* are generally more hairy and darker than those of *B. indica.*

Material: INDIA: U. P. : Dehra Dun, Sulphur Springs 18. vi. 1976, 12 Larvae (8♂♂; 4♀♀). A. Kumar. Coll; Sulphur Springs 9. vii. 1976, 7 larvae (3♂♂; 4♀♀), 1 larva (♂) emerged on 22. vii. 1976, A. Kumar Coll; Rajpur, 31. v. 1976, 3 larvae (♀♀), A. Kumar Coll; Tehri, Lakhwar, 2. vii. 1976, 5 Larvae (2♂♂, 3♀♀), A. Kumar, Coll. (All material in last instar).

Distribution: India: Meghalaya: Shillong; W. Bengal; U. P. : Dehradun, Chamoli, Pauri, Tehri and Nainital (U. P. Himalayas); Sikkim.

Acknowledgements :– Our grateful thanks are due to Dr. B. S. Lamba, Deputy Director and Dr. Asket Singh, Superintending Zoologist, Zoological Survey of India, Dehra Dun, for the permission to undertake the present work, laboratory facilities and encouragement; and to Dr. Philip S. Corbet, University of Canterbury, Christchurch, New Zealand. for valuable suggestions.

REFERENCES

CORBET, P. S. (1962) *A Biology of Dragonflies.* Withereby Ltd., London, 247 pp.

FRASER, F. C. (1919) Description of new Indian Odonata larvae and exuviae. *Rec. Indian Mus.*, **16** : 459–468.

FRASER, F. C. (1928) Indian Dragonflies. Pt. 32. Epallaginae Larvae. *J. Bombay nat. Hist. Soc.*, **33** : 301.

FRASER, F. C. (1933) *Fauna of British India : Odonata.* I. Taylor & Francis Ltd., London; 423 pp.

FRASER, F. C. (1934) *Fauna of Brisish India: Odonata* II. Taylor & Francis Ltd., London, 398 pp.

FRASER, F. C. (1957) *A Reclassification of the Order Odonata.* R. Zool. Soc., N. S. W., Hanbook No. 12.

KUMAR, A. (1973) Descriptions of the last instar larvae of Odonata from the Dehra Dun Valley (India), with notes on biology. I. (Suborder Zygoptera). *Oriental. Ins.*, **7** : 83–118.

LAIDLAW, F. F. (1917) A list of dragonflies recorded from Indian Empire with a special reference to the collection of Indian Museum. *Rec. Indian Mus.*, **13** : 321–348.

LIEFTINCK, M. A. (1956) Revision of the genus *Argiolestes* SELYS (Odonata) in New Guinea and the Molluccas, with notes on the larval forms of Megapodagrionidae. *Nova Guinea* (n. s.). **7**: 59–121.

LIEFTINCK, M. A. (1958) A review of the genus *Idiocnemis* SELYS in the Papuan Region, with notes on some Larval forms of the Platycnemididae (Odonata). *Nova Guinea* (n. s.). **9** : 253–292.

LIEFTINCK, M. A. (1962) On the problem of Intrinsic and Adaptive characters in Odonata Larvae. *XI Int. congr. Ent.*, Vienna (1960). **3** : 5 pp.

NEEDHAM, J. G. (1911) Description of dragonfly nymphs of the subfamily Calopteryginae (Odonata). *Ent. News*, **22** : 145–154.

WILLEY, R. L. (1955) A terrestrial damselfly nymph (Megapodagrionidae) from New Caledonia. *Psyche, Camb.*, **62** : 137–144.

WILLIAMS, F. X. (1936) Biological studies in Hawaiian waterloving insects. Odonata or Dragonflies. *Proc. Hawaii. ent. Soc.*, **9** : 237–349

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 231 *to* 235

SOME GENERA OF ANTHOCORINAE (HETEROPTERA : ANTHOCORIDAE) FROM SOUTH INDIA

N. MURALEEDHARAN
Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta, India 700012

(*Received 20 May 1977*)

This paper accounts 11 species of anthocorids belonging to four genera viz., *Anthocoris* Fallen, *Blaptostethus* Fieber, *Montandoniola* Poppius and *Orius* Wolff. Of these, *Anthocoris nilgiriensis* and *Orius* (*Heterorius*) *dravidiensis* are new to science.

Our knowledge of South Indian Anthocoridae is restricted to the work of Ghauri (1972) who described 2 species of *Orius* and later a few more species of anthocorids were described by Rajasekhara (1973) and Muraleedharan & Ananthakrishnan (1974, 1974a). The present paper gives a comprehensive account of four important genera of Anthocorinae namely *Anthocoris* Fallen, *Blaptostethus* Fieber, *Montandoniola* Poppius and *Orius* Wolff from this part of the country. All specimens were collected by the author.

Genus **Anthocoris** Fallen

Anthocoris Fallen, 1814, *Spec. Nova. Hemipt. Disp. Meth.*, : 9.

Type : *Anthocoris nemorum* (Linn.)

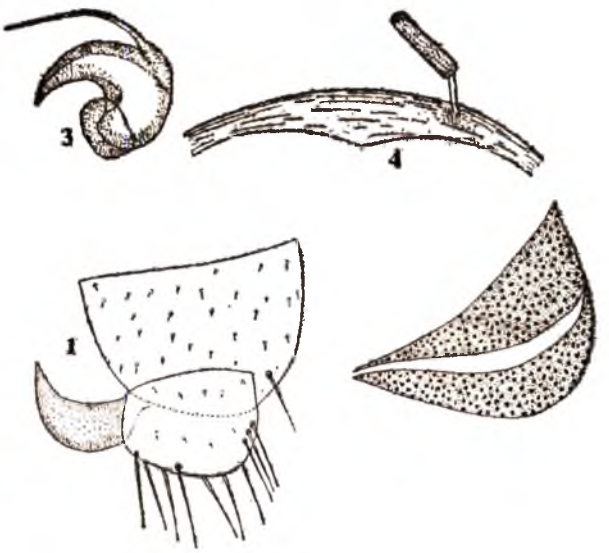
Body elongate, oval and mildly pubescent. Eyes not touching anterior margin of pronotum, ocelli placed near posterior border of eyes. Rostrum short, reaching base of forecoxae. First antennal segment almost reaching apex of head, second longest, third and fourth fusiform. Prothorax with well developed collar, lateral margins nearly straight and posterior margin concave. Scent gland canal straight or slightly bent. Apex of abdomen with macrochaetae. Ovipositor well developed.

Poppius (1909) recorded two species, *A. annulipes* Poppius and *A. indicus* Poppius, from N. E. India and the present discovery is new to South India.

1. **Anthocoris nilgiriensis**, sp. nov. (Figs. 1–2)

Colour : Body black. Rostrum brown with apex pale brown; antennal segments uniformly deep brown. Pronotum and scutellum deep brown. Hemelytra with embolium, corium and clavus yellowish brown, cuneus deep brown: membrane clouded. All femora black, tibiae black in females and yellowish in males; all tarsi yellow. Ventral side of thorax and abdomen black.

	Measurements in mm	
	Male	Female
Length of head	0.50–0.53	0.52–0.54
Width of head across eyes	0.36–0.39	0.40–0.40
Length of rostrum	0.72–0.78	0.80–0.80
Length of antennal segment I	0.12-0.14	0.16-0.16
,, II	0.46-0.49	0.42-0.44
,, III	0.30-0.33	0.30-0.30
,, IV	0.31-0.33	0.30-0.30
Length of pronotum	0.40–0.44	.45–0.45
Greatest pronotal width	0.85–0.91	0.90–0.93
Total length of body	2.50–2.67	2.70–2.90



Figs. 1-2. *Anthocoris nilgiriensis*, sp. nov. 1. abdominal apex of male showing paramere; 2. scent gland. Figs. 3-4. *Orius dravidiensis*, sp. nov. 3. male genitalia; 4. intersegmental membrane between VII-VIII showing copulatory tube.

Structure : Body elongate, setose. Head much longer than wide across eyes. Rostrum attaining base of fore coxae. Pronotal collar well developed, posterior margin deeply concave and lateral margins straight. Hemelytra completely covering abdomen; membrane with four veins. Legs slender and unarmed. Ostiolar canal slightly bent anteriorly. Paramere curved like a hook.

Holotype ♂, INDIA: TAMILNAD, Ooty, Nilgiri Hills, 23.ii.1973; Paratypes 3♂♂, 1♀ data same for holotype (All in Z.S.I. Coll.).

This species is close to *A. annulipes* Poppius in general appearance, but can be separated by the colour of tibiae and shape of paramere.

Genus **Blaptostethus** Fieber

Blaptostethus Fieber, 1860, *Wien ent. Mschr.* **4** :270

Type : *Blaptostethus piceus* Fieber

Body long, shining and moderately pubescent. Rostrum long, surpassing anterior coxae. Antennae with first segment reaching apex of head, second long and stout, third and fourth segments filiform.Pronotal collar obsolete, lateral margins straight and posterior margin slightly concave. Forefemora thickened, armed with a few spines; anterior and mid tibiae with 'fossa spongiosa'. Long setae present at apex fof abdomen; ovipositor well developed and a double copulatory tube present in females.

2. Blaptostethus kambu Rajasekhara

Blaptostethus kambu Rajasekhara, 1973, *Ann. ent. Soc. Amer.*, **66** (1) :87.

Material : 1♀ INDIA : TAMILNADU, Kallar, 13.vii.1973.

This species was first recorded from Mysore.

3. Blaptostethus pallescens Poppius

Blaptostethus pallescens Poppius, 1909 *Acta.Soc.Sci.Fenn.*, **37** (9) : 41.

Material : 2 ♂♂,1 ♀, INDIA: TAMILANADU, Madras, 7. i. 1972; 1 ♀, Coimbatore, 8. xii. 1973.

Remarks : This species had been recorded earlier from East Africa, Madagascar and Bombay.

KEY TO SPECIES OF *BLAPTOSTETHUS*

Rostrum reaching mid coxae. Forefemora of males with two or three short spines..... ..... *pallescens* Poppius

—Rostrum not reaching mid coxae. Forefemora of males with five or six long spines..... ..... *kambu* Rajasekhara

Genus **Montandoniola** Poppius.

Montandoniola Poppius, 1909, *Acta Soc. Sci. Fenn.*, 37 (9): 30. Type: *Montandoniella moraguesi* Puton.

Body elongate, oval and glabrous. Head longer than broad. Rostrum reaching up to base of forecoxae; second antennal segment very stout and setose. Anterior margin of prothorax constricted, lateral margins straight and posterior margin a little concave. Scutellum broad and transversely depressed. Hemelytra covering entire abdomen, costal margin parallel. Legs slender. Ovipositor well developed and copulatory tube present.

4. **Montandoniola moraguesi** (Puton)

Montandoniella moraguesi Puton, 1896, *Rev. d' Ent.***15** : 232 *Montandoniola moraguesi*: Poppius, 1909, *Acta. Soc. Sci. Fenn.* **37**(9): 30.

Material : 2♂♂, 2♀♀, INDIA : Madras, 18.i.1971 ; 1♂, 3 ♀♀, TAMILNADU, Courtallam, 16.vii.1971; 2♀♀, Nilgiri Hills, 8.xi.1971; 1♂, 1♀, KERALA, Palghat, 10.x.1972.

Remarks : This species had been recorded from India, Egypt, Canary Islands, Japan, S. America, Spain, France and Italy. *M. moraguesi* has been found always in association with thrips, inhabiting leaf galls all over S. India (Muraleedharan and Ananthakrishnan, 1971).

Genus **Orius** Wolff

Orius Wolff, 1811, *Icones cimicum*, **5** : 4.

Type : *Salda niger* Wolff

Body small, flat and oval; head broad, rostrum reaching base of forecoxae; antennal segments I and II stout, III and IV fusiform. Pronotum broad, trapeziform, posterior margin concave and disc transversely callous. Hemelytra with embolium narrow, claval suture depressed and membrane with three veins and middle vein obscure. Ovipositor and copulatory tube well developed.

The genus consisting of four subgenera *Orius* S. Str. Wolff, *Heterorius* Wagner, *Dimorphella* Reuter and *Microtrachelia* Blote, is represented in India by three subgenera only; *Microtrachelia* not recorded from here so far.

5. Orius (Orius) niger aegyptiacus Wagner

Orius (*Orius*) *niger aegyptiacus* Wagner, 1952, *Notul. ent.* 32 : 33.

Material : 2♂♂, 1♀ INDIA : TAMILNADU, Madras, Tambaram, 14.ix.1971.

This subspecies of *Orius niger* Wolff was first described from Egypt (Wagner, 1952) and later from Nepal (Ghauri, 1972). The present discovery is a new record for India.

6. Orius (Orius) shyamavarna Muraleedharan and Ananthakrishnan

Orius shyamavarna Muraleedharan and Ananthakrishnan, 1974, *Oriental Ins.* 8 (1) : 39–40.

Presence of long setae on angles of pronotum, confluent callosity and nature of male genitalia justifies the inclusion of this species under *Orius S.* Str.

7. Orius (Orius) trivandrensis Muraleedharan and Ananthakrishnan *Orius trivandrensis* Muraleedharan and Ananthakrishnan, 1974, *Oriental Ins.* **8** (1) : 40.

The species belongs to *Orius* s. str.

8. Orius (Heterorius) dravidiensis, sp. nov. (Figs. 3–4).

Colour: Head black with antennae and rostrum pale yellow. Prothorax, scutellum and ventral side of thorax black. Legs pale yellow. Hemelytra with corium and clavus brown, cuneus dark, membrane clear.

	Measurements in mm	
	Male	Female
Length of head	0.24–0.25	0.24–0.27
Width of head across eyes	0.30–0.33	0.30–0.34
Length of rostrum	0.40–0.42	0.40–0.43
Length of antennal segment I	0.08–0.10	0.08–0.10
,, II	0.18–0.18	0.18–0.20
,, III	0.12–0.14	0.12–0.15
,, IV	0.15–0.17	0.16–0.18
Length of pronotum	0.25–0.27	0.27–0.30
Maximum width of pronotum	0.69–0.71	0.70–0.73
Total length of body	1.52–1.59	1.55–1.62

Structure: Body mildly setose. Head a little wider than long; rostrum moderately long, reaching base of forecoxae. Antennae a little shorter than width of pronotum. Disc of pronotum deeply punctate, devoid of long setae and callosities confluent; lateral margins straight and posterior margin concave. Legs slender, foretibiae of males armed with a long row of black spurs. Hemelytra complete: membrane with three veins. Paramere with conus sharply pointed, flagellum moderately long and thin, denticulus absent. Copulatory tube of female short.

Holotype ♂ INDIA : TAMILNADU, Tanjore, 7. iv. 1972; **Paratypes** 12 ♂♂, 20 ♀ ♀ data same as holotype.

Orius dravidiensis belongs to the subgenus *Heterorius* on the basis of pronotal characters. It closely resembles *Orius* (D.) *latibasis* Ghauri in general appearance but can be separated by the confluent callosities of pronotum and sharply pointed 'Conus' of male genitalia.

9. Orius (Dimorphella) latibasis Ghauri *Orius (Dimorphella) latibasis* Ghauri, 1972, *J. nat. Hist.,* **6** : 415–416.

This species was originally recorded from Bangalore.

10. Orius (Dimorphella) maxidentex Ghauri *Orius (Dimorphella) maxidentex* Ghauri 1972, *J. nat. Hist.,* **6** : 414–415.

Material : 2♂♂, 2♀ ♀, INDIA : TAMILNADU, Coimbatore, 20. ii. 1972 ; 2♂♂, 9♀ ♀, TAMILNADU, Kovilpatti, 28.ix.1971.

This species is widely distributed in South India. Also recorded from W. Pakistan & Sudan (Ghauri, 1972).

11. Orius tantillus (Motschulsky) *Anthocoris tantillus* Motschulsky, 1863, *Bull. Soc. Nat. Moscou.,* (3) **36** : 89.

Orius tantillus : Ghauri, 1972, *J. nat. Hist.,* **6** : 411.

Material : 4♂♂, 34♀ ♀, INDIA : KERALA, Munnar, 2. iv. 1972; 1♂, 15♀ ♀, TAMILNADU, Madurai, 14. ix. 1971; 2♂♂, 19♀ ♀ TAMILNADU, Coimbatore, 22. vii. 1973.

The subgeneric characters of *Orius* had been discussed by Wagner (1952) and Pericart

(1967) and that of *O. tantillus* by Ghauri (1972). Nevertheless this species cannot be included in any of the known subgenera with certainty since it shares the characters of *Dimorphella* and *Heterorius*.

KEY TO SPECIES OF *ORIUS* FROM SOUTH INDIA

1. Angles of pronotum provided with long setae 2

—Angle of pronotum devoid of long setae 4

2. Copulatory tube of female short. Flagellum of paramere not much longer than Conus .. .. *niger aegyptiacus* Wanger

—Copulatory tube of female long. Flagellum of male genitalia much longer than Conus 3

3. Paramere without denticulus ..... *shyamavarna* Muralee. and Anan.

—Paramere with denticulus ..... *trivandrensis* Muralee. and Anan.

4. Callosities of pronotum separate 6

—Callosities of pronotum confluent ..... *dravidiensis* sp. nov.

5. Paramere without denticulus ..... *latibasis* Ghauri

—Paramere provided with denticulus 5

6. Apex of Conus sharply pointed; flagellum and denticulus form a tripartite structure ..... *tantillus* Motschulsky

—Apex of Conus blunt; flagellum and denticulus not forming tripartite structure ..... *maxidentex* Ghauri

Acknowledgements:– I am thankful to Dr. T. N. Ananthakrishnan, Director, Zoological Survey of India for giving valuable suggestions and necessary facilities during the course of this study.

REFERENCES

GHAURI, M. S. K. (1972) The identity of *Orius tantillus* (MOTSCHULSKY) and notes on other Oriental Anthocoridae (Hemiptera: Heteroptera). *J. nat. Hist.*, **6**: 409–421.

MURALEEDHARAN, N. & T. N. ANANTHAKRISHNAN (1971) Bionomics of *Montandoniola moraguesi* (PUTON) (Heteroptera: Anthocoridae), a predator on gall thrips. *Bull. ent.*, **12**: 4–10.

MURALEEDHARAN, N. & T. N. ANANTHAKRISHNAN (1974) New and little known species of *Orius* WOLFF from India (Hem. Anthocoridae). *Oriental Ins.*, **8** : 37–41.

MURALEEDHARAN, N. & T. N. ANANTHAKRISHNAN (1974a) The genus *Buchananiella* REUTER from India with description of a new species (Heteroptera: Anthocoridae). *Oriental Ins.*, **8**: 33–35.

PERICART, J. (1967) Note au subjet des caracters subgeneriques chez les *Orius* Paleartiques (Heteroptera: Anthocoridae). *Bull. Soc. linn. Lyon.*, **36** : 148–154.

POPPIUS, B. (1909) Beitrage zur Kenntnis der Anthocoriden. *Acta Soc. Sci. fenn.*, **37**: (9)1–43.

RAJASEKHARA, K. (1973) A new species of *Blaptostethus* (Hemiptera: Anthocoridae) from Mysore, India. *Ann. ent. Soc. Am.*, **66**: 87.

WAGNER, E. (1952) Die europaischen Arten der Gattung *Orius* WFF. (Hem. Anthocoridae). *Notul. ent., Helsingfors,* **32** : 22–59.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 237 *to* 240

A NEW INDIAN GRASS GALL-MIDGE (ITONIDIDAE : CECIDOMYIIDAE : DIPTERA)

S. N. Rao & R. M. Sharma
Department of Zoology, Marathwada University, Aurangabad, India 431004

(*Received 20 May 1977*)

This paper deals with a new genus *Bothriochloamyia* accommodating midges reared from the galls on the ear heads of the grass *Bothriochloa pertusa* (L) A. Camus (*Andropogon pertusus*) (L) (Wild.) in the Marathwada University Campus, Aurangabad. The relative position of the genus along with others is also given.

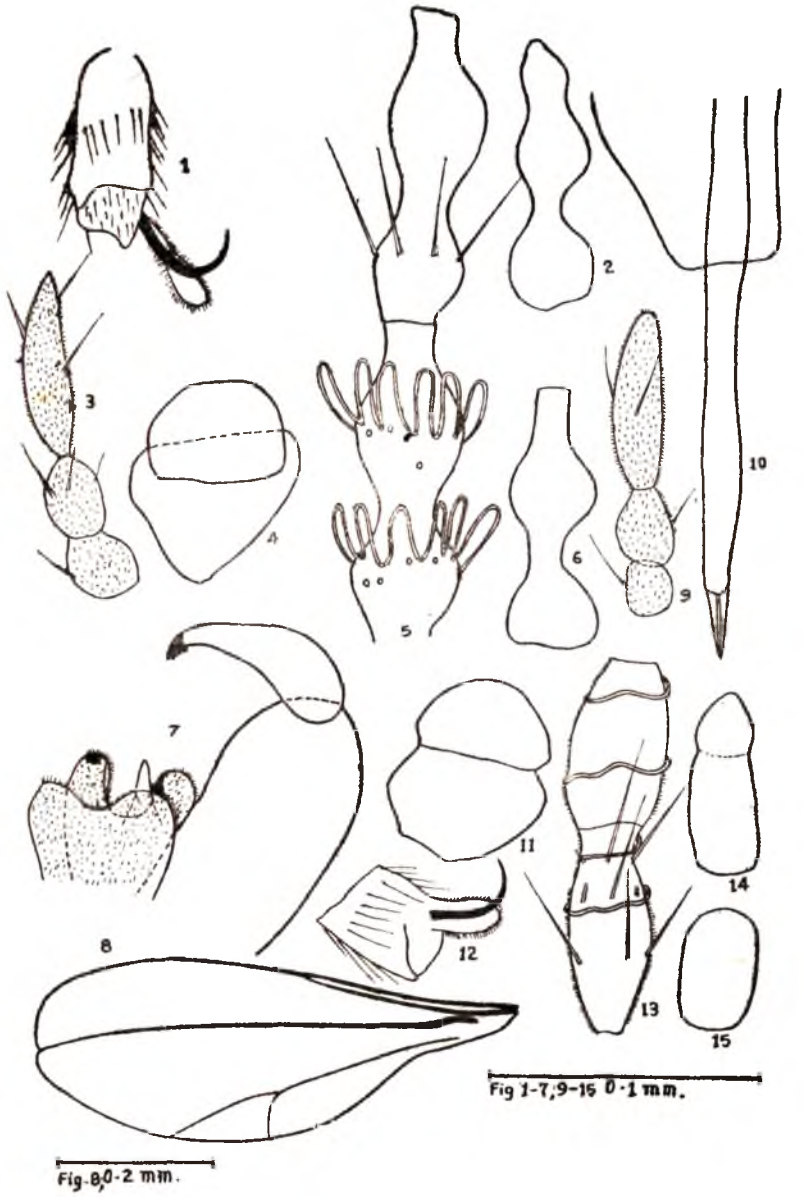
Bothriochloamyia [1]; Gen. nov.

Eyes confluent above. Trophi normal. Palpi triarticulate. Antenna with fourteen segments in both male and female: in male all flagellate segments binodose, enlargements globose with two whorls of circumfila and two whorls of long setae one on each enlargements; in female flagellate segments cylindrical, with short apical stems; circumfila low; third and fourth antennal segments not confluent. Wings hyaline, vein Rs absent, vein R5 reaching wing margin well beyond its apex; vein cu forked. Legs brown, thickly setose; claw simple on all legs, sickle shaped, empodium as long as claw in male, shorter in female, Genitalia: brown, basal clasp segment large and oval, terminal clasp segment slender, ending in a tooth, dorsal plate broadly bifid, pubescent, lobes rounded apically: sub-dorsal plate longer than dorsal plate, deeply incised in the middle, emarginate medially lobes rounded apically; style short, slender, tip rounded. Ovipositor long, retractile, aciculate.

Type of the genus: Bothriochloamyia orientalis ; gen. et. sp. nov.

Male : Body 1.5 mm long, Palpus (Fig. 3) triarticulate, first segment globose, (8:8), second segment, cylindrical longer than first, length 1.40 × its maximum thickness (14 : 8), third segment cylindrical, longest of all, length 4 × its maximum thickness (28 : 7). Antenna : 1.24 mm long, shorter than body, 2—12 segmented flagellar segments all binodose, enlargements globose with one whorl of long setae and a whorl of circumfila in middle; scape (Fig. 4) cup-shaped, sligtly wider than long (12 : 13), pedicel (Fig. 4) sub globose, shorter than scape ; third segment (Fig. 5) with a very small basal prolongation, basal enlargement 0.30 the length of the segment (41: 14) and as long as thick (14 : 14) basal stem 0.42 (14 : 6) the length of the basal enlargement and little less than its own thickness (5 : 6) apical enlargement little longer than the basal enlargement, 0.36 (15 : 41) length of the segment and as long as thick 15 : 15), apical stem longer than basal stem and 1.30 × its maximum thickness (8 : 6); fourth segment similar to the third segment (41 : 41); fifth, sixth and seventh segments slightly shorter than the third segment (40 : 41) eighth to eleventh segments similar to the sixth; twelfth segments shorter than eleventh (37 : 40), basal enlargement 0.27 the length of the segment (10 : 37) wider than long (10 : 11) basal stem 0.50 the length of the basal enlarge-

[1] Name associated with the host plant *Bothriochloa pertusa* (L) A. Camus (Graminae).



Bothriochloamyia orientalis Gen. et. sp. nov. (Fig. 1-8. male; 9-15. female).

1–claw; 2–terminal antennal segment; 3–palpus; 4–scape and pedicel; 5–third and fourth antennal segments; 6–penultimate antennal segment; 7–genitalia; 8–wing; 9–palpus; 10–ovipositor; 11–scape and pedicel; 12–claw; 13–third and fourth antennal segments; 14–terminal antennal segment; 15–penultimate antennal segment.

ment (5 :10) and 1.66 × as long as thick (5 : 3), apical enlargement longer than basal enlargement (12 : 10), 0.32 the length of the segment (12 : 37) and slightly longer than wide (12 : 11), apical stem shorter than apical enlargement (10 : 12) and 2.50 × as long as thick (10 : 4), penultimate segment (Fig. 6) similar to the twelfth segment; terminal segment (Fig. 2) as long as penultimate segment (36 : 36), basal enlargement 0.30 the length of the segment (11 : 36) and as long as thick (11 : 11), basal stem 0.63 the length of the basal enlargement (7 : 11) and 2.33 × as long as thick (7 : 3), apical enlargement and stem 0.55 the length of the segment (20 : 36) and 2.22 × as long as thick, (20 : 9) apical stem in the form of a knob. Wing (Fig. 8) hyaline, 2.70 × as long as broad (68 : 24) vein R5 reaching wing margin well beyond its apex and interrupting costa at its union, vein cu forked. Legs: long, densely hairy, metatarsus shorter than second tarsal segment, the latter longest of all, terminal segment longer than metatarsus (27:25); claw (Fig. 1) simple on all legs, sickle shaped, empodium as long as claw (13 : 13). Genitalia (Fig. 7) basal clasp segment sparsely setose, oval, 2.50 × as long as broad (50 : 20); terminal clasp segment slender, evenly curved, thicker at base than at apex, little more than thrice as long as broad, (25 : 8) ending in a tooth with a tuft of stiff and short hairs at the base; dorsal plate (15: 20) pubescent, broadly and shallowly incised in the middle, lobes rounded apically, subdorsal plate broadly and deeply incised in the middle, hairy, emarginate medially, lobes rounded; style short extending upto the subdorsal plate, slender rounded at tip.

Female: Body 2.2 mm long, including ovipositor. Palpus (Fig. 9) triarticulate, sparsely setose, first segment 1.33 × as long as thick (8:6); second segment cylindrical 1.37 × as long as thick (11:8), third segment cylindrical longest of all and 4 × as long as thick (24:6). Antenna: 0.76 mm long, shorter than body, 2—12 segmented, flagellar segments cylindrical, with very short apical stems, low circumfila encircling the enlargements and three whorls of long setae; scape (Fig. 11) cupshaped wider than long (16:20), pedicel (Fig. 11) subglobose, wider than long (16 : 20), third segment (Fig. 13) longest of all with a small basal prolongation, enlargement 0.80 the length of the segment (26 : 31) and 1.16 × as long as thick (26 : 12), stem as long as thick (5 : 5); fourth segment (Fig. 13) shorter than third, (23 : 31) enlargement 0.87 the length of the segmnt and 1.66 × as long as thick, (20 : 12) stem thicker than long (3 : 5), fifth to seventh segments similar to the fourth segment; eighth segment slightly shorter than fifth (21 : 22), ninth to twelfth segments similar to eighth segment; penultimate segment (Fig. 15) shorter than eighth (18: 21) and shortest of all, enlargement 0.90 the length of the segment (19 : 18) and 1.60 × as long as thick (16 : 10) stem very short; terminal segment (Fig.14) longer than penultimate segment, enlargement 0.67 the length of the segment (15 : 22) and 1.50 × as long as thick (15 : 10) stem in the form of a knob, measuring 0.46 the length of the enlargement and slightly longer than thick. Wing and legs: as in male; claw (Fig. 12) simple on all legs, evenly curved, empodium broad, shorter than claw. Ovipositor: (Fig. 10) long, retractile, aciculate, terminal lamellae lanceolate.

Holotype: ♂ dissected and mounted on slide labelled as reared from grass earheads of *Bothriochloa pertusa* (L.) A. Camus, University Campus; Aurangabad, INDIA, MAHARASHTRA, R. M. Sharma coll. 10. xi. 1975.

Allotype: ♀ dissected and mounted on slide: labelled as in holotype.

Paratypes : 3 ♀ ♀ and 5 ♂ ♂ dissected and mounted on slides and many males and females in alcohol, data as in holotype.

This new genus runs very close to *Bungomyia* Nayar (1949). It can be distinguished from *Contarinia* which has some common characters, in the possession of the triarticulate palpi, in the third vein uniting the costa well beyond the apex of the wing. The relative position of this new genus, *Bothriochloamyia*, is as below:

1. Palpi uniarticulate, wings spotted, dorsal and ventral plates bifid, dorsal plate shorter than ventral plate, ovipositor long..... .....*Sissudiplosis* Mani
—Palpi triarticulate.....2

2. Third and fourth antennal segments confluent, wings short and rounded, fork of fifth vein rudimentary, basal clasp segment quadrate and large terminal clasp segment bidentate at apex with a tuft of hairs; style long.....*Bungomiya* Nayar

—Third and fourth antennal segments not confluent, wings moderately long, fork of fifth vein distinct, basal clasp segment large and oval, terminal clasp segment with a single dent at apex with a tuft of short hairs; style short.... .....*Bothriochloamyia*, gen. nov.

Acknowledgement:– We take this opportunity to thank Dr. R. Nagabhushanam, Professor of Zoology, Marathwada University, Aurangabad,for providing necessary laboratory facilities. Thanks are also due to the authorities of the Marathwada University for awarding a fellowship to the junior author.

REFERENCES

FELT, E. P. (1921) Indian grass gall midges. *Mem.. Dep. Agric. India*, **7** (3) : 15–22.

GAGNE, R. J. (1973) *A Catalogue of the Diptera of the Oriental Region. Vol.* 1. *Suborder Nematocera* : P. 497.

GROVER, P. (1967) A new grass midge from India. *Cecidol. Indica*, **2** (3) : 151–161.

GROVER, P. (1968) A new grass midge belonging to the genus *Tristephanus* KIEFFER. *Cecidol. Indica*, **3** (3): 165–172.

MANI, M. S. (1934) Studies on Indian Itonididae (Cecidomyiidae : Diptera). *Rec. Indian Mus.*, **36** : 418.

MANI, M. S. (1946) Studies on Indian Itonididae (Cecidomyiidae : Diptera). VIII. Keys to the genera from the Oriental Region. *Indian. J. Ent.*, **7** (1 & 2) : 189–235.

NAYAR, K. K. (1949) New Indian gall midges (Diptera : Cecidomyiidae). *Proc. R. ent. Soc London*, **18** (5–6): 85.

RAO, S. N. (1955) Catalogue of Oriental Itonididae (Cecidomyiidae: Diptera). *Agra. Univer. J. Res.*, **4** (1) : 213–282.

RAO, S. N. & A. B. SAKSENA (1959) New grass gall midge (Itonididae: Cecidomyiidae) from India. *J. zool. Soc. India*, **11** (2): 133–138.

RAO, S. N. & P. D. ADWANT (1971) Studies on Indian Cecidomyiidae (Itonididae : Diptera) from Marathwada. III. New Indian gall midges of the sub family Itonidinae. *Marath. Uni. J. Sci.*, **10** (3) : 187–196.

Entomon 1977, *Vol.* 2, *No.* 2, *pp.* 241 *to* 242

BRIEF COMMUNICATIONS

A NEW SPECIES OF GENUS *FARYNALA* DWORAKOWSKA 1970, FROM INDIA (HOMOPTERA : CICADELLIDAE : TYPHLOCYBINAE)

BALDEV SHARMA
Department of Biosciences, University of Jammu, Jammu, India 180001

(*Received 6 December 1976*)

***Farynala malhotri* sp. nov. has been described recording genus *Farynala* Dworakowska (1970) for the first time from India.**

Genus *Farynala* was erected by Dworakowska (1970) based only on its type species *Farynala novica* Dwor. from Vietnam. So far no other species has been added to this genus. This paper adds one more new species to this genus, collected from Jammu division of J & K State, thus recording genus *Farynala* for the first time from India.

Farynala malhotri sp. nov. (Figs. 1–10)

Tegmen: (Fig. 3) Elongate, equally broad throughout; I apical cell short, its base angulate; II broadest apically; III petiolate, petiole shorter than cell itself.

Hindwing: Vennal veins separate, Cu2 joining submarginal vein in basal half of wing; apical cells 2, apically open.

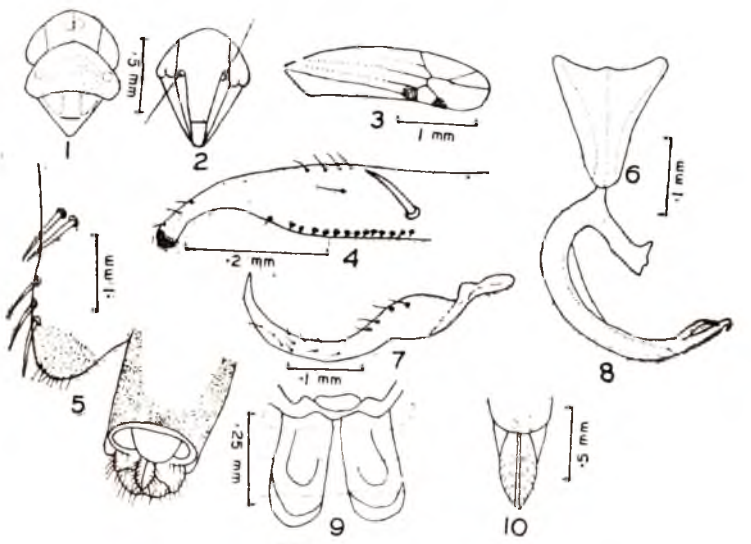
Male genitalia: Subgenital plate (Fig. 4) almost parallel sided at basal 2/3 then suddenly narrowed; single large macroseta near base, row of thick microsetae along outer margin and on tip present. Pygofer (Fig. 5) obtusely rounded apically; 2 groups of macrosetae (2 & 3) and a few microsetae at apex present. Anal tube well sclerotized. Connective (Fig. 6) flat, wedge-shaped. Paramere (Fig. 7) broadest just after articulation point, then narrowed and acutely bent laterad; many microsetae on broadened and posterior portion present. Aedeagus (Fig. 8) with dorsal apodeme well developed, without preatrium; shaft regularly bent dorsad, apically bifurcated, two furca unequal; gonopore at base of bifurcation.

Female: 7th sternum (Fig. 10) convex posteriorly; ovipositor and pygofers terminating at same level.

Form : (Fig. 1) Head as broad as pronotum ; vertex longest medially, obtusely produced in front of eyes ; median suture entire. Pronotum convex anteriad, slightly concave posteriad. Scutellum transversely impressed pre-apically. Ocelli absent. Face (Fig. 2) much longer than broad, frontoclypeus narrow, long. Abdominal apodemes (Fig.9) well developed, traversing half the 3rd abdominal segment. Hind femoral chaetotaxy 2,1,1.

Colour : Pale yellowish ; vertex with 2 rounded (one on each side of median suture, pronotum with discal large hyaline areas. Eyes pale stramineous. Scutellum with basal triangular areas yellowish. Thoracic terga slightly brownish black.

Measurements in mm : (Female in parenthesis) total length with wings, 3.0 (3.3) ; without wings, 1.9 (2.3) breadth head, .7 ; vertex .25/ .35 ; pronotum



Figs. 1–10. *Farynala malhotri* sp. nov. 1–head and thorax, dorsal view; 2–face; 3–right tegmen; 4–left male subgenital plate; 5–pygofer and anal tube; 6–connective; 7–paramere; 8–aedeagus (lat.); 9–abdominal apodemes; 10–tip of the abdomen of female.

.475/ .7 ; scutellum, .3/ .45 ; face, .75/ .4 ; tegmen, 2.6/ .6 ; length/breadth.

Holotype : ♂ with abdomen on slide from INDIA : JAMMU & KASHMIR Manthal upon *Ficus* sp., 9.ii.1974, B. Sharma Coll.

Paratypes : 2 ♂♂ with abdomen of one on slide ; other data as for holotype.

Allotype : Many ♀ ♀, data as for holotype.

In colour markings etc. the sp. nov. resembles *F. novica* Dwor. but can be readily distinguished by : (1) Absence of any scaly setae on the inner side of the basal tubercle of paramere; (2) longer abdominal apodemes; (3) posterior margin of pygofer being rounded (not pointed like *F. novica*; (4) apical furca of aedeagus being rolled and unequal. The author takes delight in naming the new species after Prof. Y.R. Malhotra, his esteemed teacher and supervisor during this work. Type material of the newly described species is deposited in the museum, Department of Biosciences, University of Jammu, Jammu, India 180001.

Acknowledgements :– Author is grateful to Prof. Y. R. Malhotra, Head of the Department of Biosciences, University of Jammu for his constant encouragement and criticism during this work. To the University of Jammu, author is thankful for providing U. G. C. Research Fellowship during this work.

REFERENCE

DWORAKOWSKA, I. (1970). On some East Palaearctic and Oriental Typhlocybini (Homoptera, Cicadellidae, Typhlocybinae). *Bull. Acad. pol. Sci. Cl. II Sér. Sci. biol.*, **18** (4): 211–217.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp* 243 *to* 245

TWO NEW SPECIES OF *CHRYSOPA* (NEUROPTERA : CHRYSOPIDAE) FROM INDIA

S. K. GHOSH
Zoological Survey of India, Western Regional Station, Poona-5
India

(*Received 4 July 1977*)

Chrysopa (*Anisochrysa*) *kinnaurensis* **sp. nov. and** *Chrysopa* (*Anisochrysa*) *chailensis* **sp. nov. (Neuroptera: Chrysopidae) are described from Himachal Pradesh, India.**

The author while studying the material collected from Himachal Pradesh, came across two new species which belong to the subgenus *Anisochrysa* because of the presence of tignum, gonarcus and gonapsis. The type specimens will in due course be deposited in the Zoological Survey of India, Calcutta.

1. Chrysopa (Anisochrysa) kinnaurensis sp. nov.

Male : *Head* : Pale brownish ; genae and clypeus reddish brown ; frons yellowish ; palpi dark brown at the tip ; antennae dark brown.

Thorax : Pronotum : broader than long ; lateral margins darker ; Meso- and Metanotum : Pale yellow blackish interruptions. Legs : yellow ; hindtibiae very much elongated than hindfemora. Wings (Figs. 1–2) : Slender, blunt at the tip ; most cross veins swollen except at ends ; pterostigma faint yellowish ; Wing veins pale yellow with dark band at the junction of the cross veins ; most crossveins dark all over or dark only at each end ; gradates dark with a faint brown cloud around each gradate ; forewings : 17–19 costal cross veins before pterostigma ; tip of the intramedian cell ends after the 1st radio-medial cross vein ; 9 radial cross veins ; number of gradates 3/5 ; hindwings : shorter than forewings ; 15 costal cross veins before pterostigma, otherwise similar to forewings.

Abdomen : (Figs. 3–6) : blackish with long hairs ; Genitalia : Gonarcus less wider than tignum ; tignum without acumen but with a deep emargination ; arcessus broad in dorsal view and tapering into a trifid apex, middle one of which more elongated than other two ; gonapsis with moderately large side pieces and the central piece stout with acute tip ; gonocristae rather large with teeth.

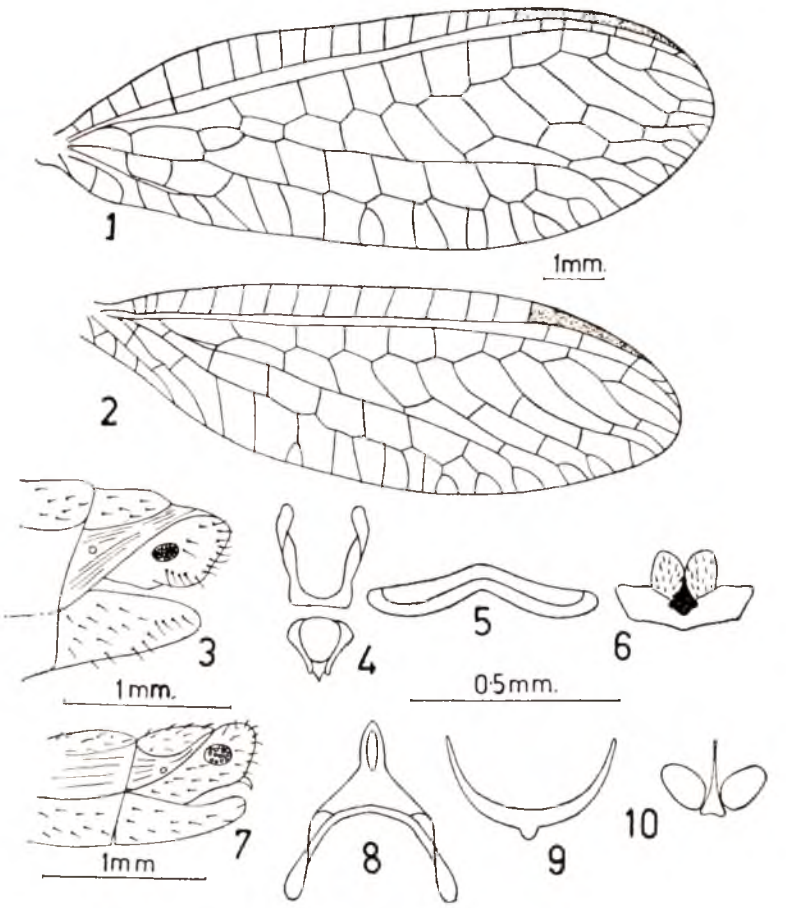
Holotype ♂ INDIA : HIMACHAL PRADESH : Pooh Kinnaur, Solan, 29.iv. 1970, Coll. K. K. Mahajan.

Paratype ♂ Collection data same as for the holotype.

The new species resembles *Chrysopa alcestes* Banks (1911) but differs in genital armature (described and figured by Adams, 1959) specially by the trifid arcessus, structure of gonapsis and by the presence of gonocristae.

2. Chrysopa (Anisochrysa) chailensis sp. nov.

Male : *Head* : Yellow ; frons and clypeus whitish; sides of the clypeus and genae



Figs. 1–6. *Chrysopa* (*Anisochrysa*) *kinnaurensis* sp. nov. Holotype male : 1. Forewing; 2. Hindwing; 3. Apex of the abdomen; 4. Gonarcus with arcessus; 5. Tignum; 6. Gonapsis and gonocrista.
Figs. 7–10. *Chrysopa* (*Anisochrysa*) *chailensis* sp. nov. Holotype male : 7. Apex of the abdomen; 8. Gonarcus with arcessus; 9. Tignum; 10. Gonapsis.

reddish ; palpi pale yellow to fuscous ; vertex and antennae pale yellow.

Thorax : Pronotum : broader than long, yellow and the anterolateral corners reddish; Meso- and Metanotum: Yellowish. Legs : Yellow. Wings : slender, subacute at tip; wing veins pale yellow; most of the cross veins dark all over or dark only at each end and swollen in the middle like *C. kinnaurensis;* gradates dark; forewings: 14 costal cross veins before pterostigma; tip of the intramedian cell ends after the 1st radio-medial cross vein; 8 radial cross veins; number of gradates 3/4 ; hindwings : shorter than forewings ; 12 costal cross veins before pterostigma; gradates 2/3.

Abdomen (Figs. 7–10) : Yellow with a median white vittata and white hairs; Genitalia : gonarcus archshaped with almost transverse central portion and slender lateral

pieces ; arcessus long in dorsal view, broad at base and tapering towards the apex ; arcessus pointed at the apex in lateral view; tignum – a narrow arch with small rounded acumen; gonapsis large, its central piece long and slender and the side pieces broad and almost rounded.

Holotype ♂, INDIA : HIMACHAL PRADESH: Chail 15–16. iv. 1972, Coll. H.P. Agarwal.

Paratype ♂, collection data same as for the holotype.

This species closely resembles the preceeding species but differs from it by the shape of the arcessus, presence of acumen in tignum and by the structure of the gonapsis.

Acknowledgements:– The author is indebted to Dr. S. Khera, Joint-Director-in-Charge, Zoological Survey of India, Calcutta for the facilities given to him to work on Neuroptera, to Dr. B. K. Tikader, Deputy Director, Zoological Survey of India, Western Regional Station, Poona for extending help in various ways and to Dr. Raj Tilak for making available the material used in this study.

REFERENCES

ADAMS, P. A. (1959) Neuroptera: Myrmeleontidae and Chrysopidae. *Insects Micronesia*, **8** : (2) : 32–33.

BANKS, N. (1911) Notes on Indian Neuropteroid insects. *Proc. ent. Soc. Wash.*, **13** : 102–103.

Entomon 1977, *Vol.* 2, *No.* 2, *pp.* 247 *to* 251

HOST-PARASITE AND HOST-PREDATOR INTERACTIONS IN THE GALL THRIPS *SCHEDOTHRIPS ORIENTALIS* ANAN. (INSECTA : THYSANOPTERA)

T. N. ANANTHAKRISHNAN & S. SWAMINATHAN
Entomology Research Unit, Loyola College, Madras, India 600034

The interactions of *Schedothrips orientalis* and its parasite, *Tetrastichus thripophonus* Waterston, as well as of its predator *Androthrips flavipes* Schmutz are discussed.

Information relating to parasitism of thrips in India is limited to *Thripoctenus maculatus* parasitising the immature stages of *Rhipiphorothrips cruentatus* Hood (Rahman & Bharadwaj, 1937), *Tetrastichus rhipiphorothripsidis* Narayanan parasitising the nymphs of *Mallothrips indicus* Ramakrishna, *Rhipiphorothrips cruentatus* Hood (Narayanan *et al.*, 1962) and *Ceranisus* sp., parasitising *Thrips tabaci* Lind. (Saxena, 1971). Present observations relate to the population periodicity of *Tetrastichus thripophonus*, a new parasitic record of thrips in India, and the inquiline-predator *Androthrips flavipes*, occurring on the *Ventilago* gall thrips *Schedothrips orientalis*, in relation to host-parasite and host-predator interactions respectively, with special emphasis on the effects of parasitization on the host.

Materials were collected from Tambaram (Chenglepet District, Tamil Nadu). The populations of the host, parastie and predator were analysed from the epiphyllous marginal leaf fold galls of *Ventilago maderasapatana*. Since the parasitic adults are free living, the number of parasitized 2nd larvae of *Schedothrips* has been taken as a reliable index of parasitic population. The parasitized larvae were fixed on a filter paper and kept inside a chimney cage covered with muslin to obtain the adults of the parasite which were fed with cotton soaked with 2% honey.

Parasitization appeared restricted to 2nd instar larvae of *Schedothrips* (Fig. 2) though occasionally prepupae and pupae were affected. Parasitized larvae, besides being deformed, stopped moulting and showed gradual swelling of the body leading to immobility. *Tetrastichus* larvae exhibited peristaltic and slight up and down movements within the host. Shortly before adult emergence the parasite displayed a rotation of 180° within the host. Emergence of the parasite from the host occurred on the 8th day of pupation through a wide slit on the ventral side of *Schedothrips* larvae between thoracic and 6th abdominal segments. The total life span of the adult parasites extended between 48 to 72 hrs under laboratory conditions. Within 24 hrs after emergence from the host they started mating which lasted for about 15 mts. A periodic vibration of the antennae of the male during copulation was noticed. Though *Tetrastichus* laid two to three eggs in the host usually only one developed.

The populatin trends (Fig. 1) show a significant decline in host population immediately following the increase in the *Tetrastichus* population in September 1976. Maintenance of the total host density at a low level till May 1977 is explainable by the increase in *Androthrips flavipes* (inquiline-predator) population whose predatory be-

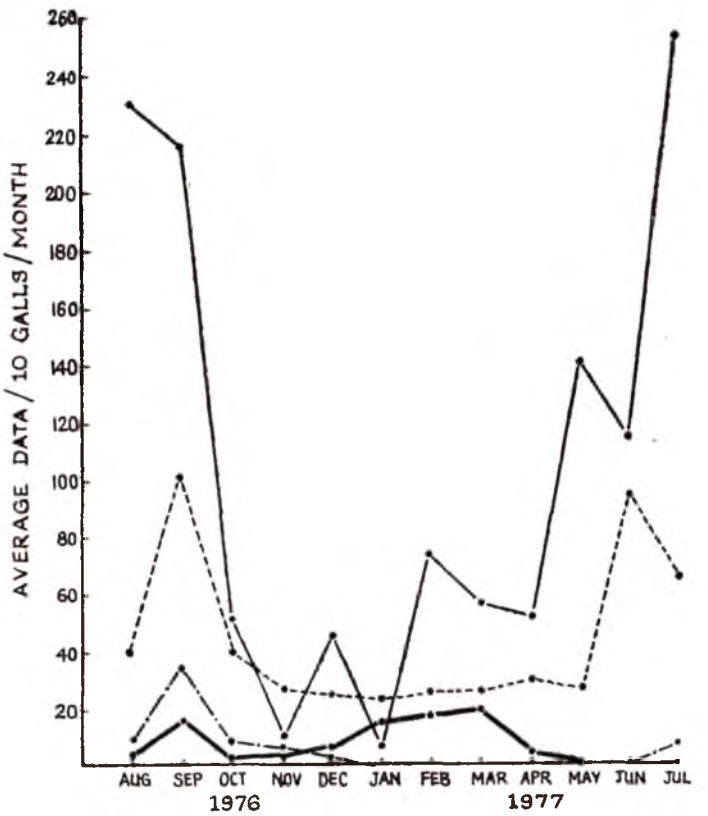


Fig. 1 : Population trends of *Schedothrips orientalis* and its parasite *Tetrastichus thripophonus and* inquiline-predator *Androthrips flavipes*. ·—· *Schedothrips orientalis* total population; · - - - · *Schedothrips orientalis* egg population; · — · — · *Tetrastichus thripophonus* population; · —— · *Androthrips flavipes* total population.

haviour has been established for the first time on a few gall thrips including *Schedothrips orientalis* (Ananthakrishnan & Varadarasan, 1977). Feeding on eggs in particular, appears to be preferred, though the predatory effect of inquiline-predator is evident on both adults and eggs of the gall maker. A significant correlation between the egg population of the host and *Androthrips flavipes* density could be observed. *Schedothrips* egg population reached a minimum as the *Androthrips* population increased in October 1976, and the resumption of the former in June 1977 after decrease of the latter in May 1977. From the observations a cumulative action of both the parasite *Tetrastichus thripophonus* and inquiline-predator *Androthrips flavipes* controlling *Schedothrips orientalis* population was evident throughout the year.

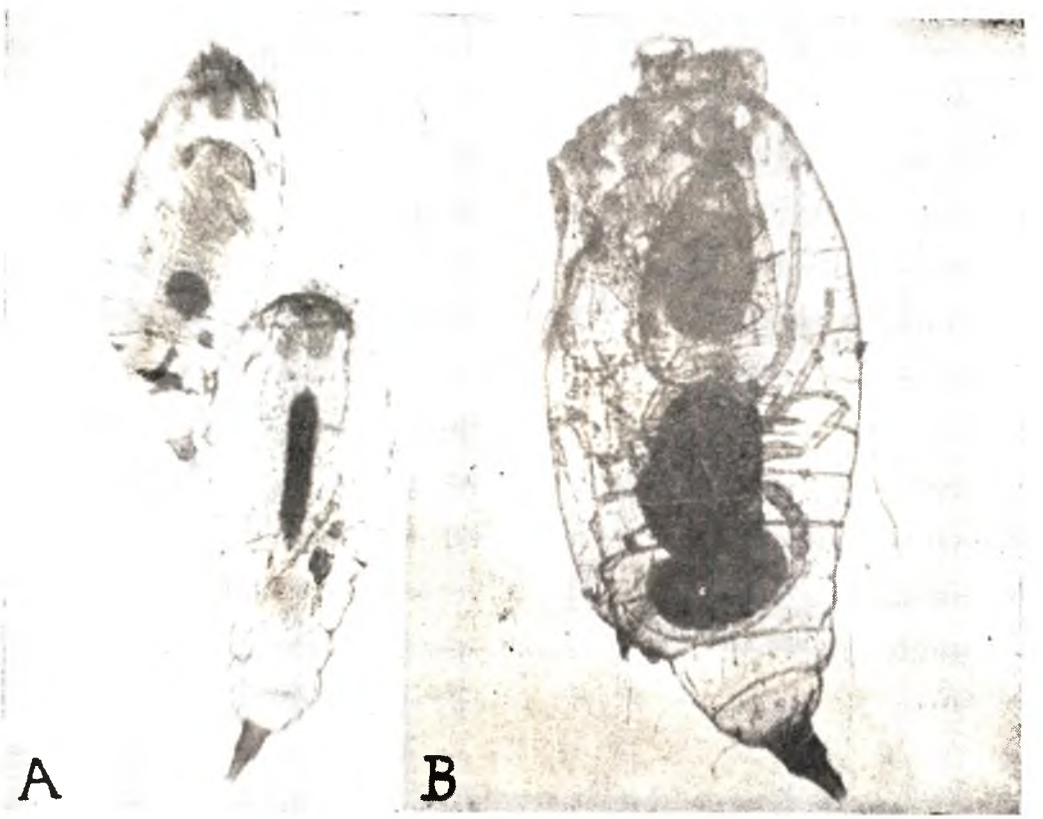


Fig. 2. (A) 2nd instar larva of *Schedothrips orientalis* showing the developing stages of the parasite. (B) 2nd instar larva of *Schedothrips orientalis* showing the mature parasite having undergone 180° rotation.

Acknowledgement:- Thanks are due to the University Grants Commission for the award of a grant during the tenure of which this work has been done.

REFERENCES

ANANTHAKRISHNAN, T.N. & S. VARADARASAN (1977) *Androthrips flavipes* SCHMUTZ (Insecta: Thysanoptera), a predatory inquiline in thrips galls. *Entomon*, **2** : 105–107.

NARAYANAN, E. S., B. R. SUBBA RAO, & M. RAMACHANDRA RAO (1962) Some new species of Chalcids from India. *Proc. nat. Inst. Sci. India*, **26** : 168–175.

RAHMAN, K. A. & N. K. BHARADWAJ (1937) The grapevine thrips (*Rhipiphorothrips cruentatus* HOOD) (Thripidae: Terebrantia : Thysanoptera). *Indian J. agric. Sci.*, **7** : 633–651.

SAXENA, R. C. (1971) Some observations on *Ceranisus* sp. (Hymenoptera: Eulophidae) parasitising *Thrips tabaci* LIND. (Thysanoptera: Thripidae). *Indian J. Ent.*, **33** : 91–92.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 253 *to* 254

EFFECT OF HOST EGG SIZE ON FECUNDITY OF *TRICHOGRAMMA FASCIATUM* (PERKINS) (TRICHOGRAMMATIDAE : HYMENOPTERA)[1]

ATMA RAM & A. K. SHARMA
Division of Entomology, Indian Agricultural Research Institute, New Delhi, India 110012

(*Received 12 March 1977*)

The eggs of the laboratory host *Corcyra cephalonica* (STAINTON) were separated by sieving into three size-groups. There was no significant difference in the fecundity of *Trichogramma fasciatum* (PERKINS) females reared from eggs of the different size-groups.

Trichogramma fasciatum (PERKINS) is a ploiphagous egg parasite of lepidopterous hosts in the New World. A culture of the Barbados strain of the parasite, obtained from the Commonwealth Institute of Biological Control, Indian Station, Bangalore, and being maintained in the parasite Laboratory of the Division of Entomology at the Indian Agricultural Research Institute (IARI), New Delhi, on the factitious host, *Corcyra cephalonica* (STAINTON), was subjected to selection for improving fecundity and sex-ratio. During the course of selection for improving fecundity of the parasite, little variation in fecundity was observed. Since the eggs of *C. cephalonica* vary in size, it was considered relevant to study the possible effect of the host egg size on fecundity.

The host eggs were separated by sieving into the following three categories according to their sizes: A: 0.350 mm, B: 0.349 to 0.300 mm and C: 0.300 mm width. The parasites were reared on these three categories of eggs for five generations, care being taken to avoid superparasitism by exposing large number of eggs to a small population of the parasite, for a short period of about 2 hours. The mated pairs from among the freshly emerged parasites were transferred to small vials and fed with dilute honey solution (1:1, v/v honey and water). The eggs were offered daily to each female till it died. While offering a fresh egg card the previous day's card was removed. The experiment was conducted at 25± 1°C and 30% R.H.

The results, in the form of averages of ten replicates, are presented in the table.

TABLE 1. Effect of host egg size on fecundity.

Size-categories of the host eggs	Average fecundity
A (> 0.350 mm)	165.6
B (0.349 to 0.300 mm)	136.3
C (< 0.300 mm)	156.8
S Em ± 8.62	N S

It is evident that there was no significant difference in fecundity of the females emerging from the three categories of the host eggs.

BOLDT *et al.* (1973) recorded differential parasitism by *Trichogramma evanescens* WESTWOOD emerging from eggs of *Sitotroga cerealella* (OLIVIER), *Galleria mellonella* (LINNAEUS) and *Pieris rapae* (LINNAEUS) and

[1] A part of Ph.D. thesis of the senior author.

T. pretiosum (RILEY) from those of *S. cerealella, G. mellonella, P. rapae, Trichoplusia ni* (HUBNER) and *Heliothis zea* (BODDIE). The highest parasitisation (67. 10%) was by adults of *T. pretiosum* emerging from eggs of *H. zea,* the biggest-sized egg, and lowest (34.58%) from those emerging from eggs of *S. cerealella,* the smallest sized egg. MARSTON & ERTLE (1973) reported that the females of *T. minutum* RILEY emerging from bigger host eggs (*Trichoplusia ni*) were more fecund than those emerging from smaller eggs (*S. cerealella*). However, no such correlation was found during present investigations. The host egg size may have some influence on fecundity of the parasite female when reared under conditions promoting superparasitism. The bigger host egg can obviously ensure a larger food supply to the larvae developing in it than the smaller egg, with the result that normal and more vigorous and hence, perhaps, more fecund females may emerge from bigger eggs. As already stated, every possible care was taken to avoid superparasitism, which appears to be a satisfactory explanation for the absence of difference in fecundity among females reared from host eggs of different sizes.

Acknowledgements:- Grateful thanks are due to the present and former Heads of the Division of Entomology, Dr. N.C. PANT and the late Dr. S. PRADHAN, for not only providing all facilities for work but also for keen interest in its progress and successful completion.

REFERENCES

BOLDT, P. E., N. MARSTON & W. A. DICKERSON (1973) Differential parasitism of several species of Lepidopteran eggs by two species of *Trichogramma*. *Environmental Entomology*, **2**: 1121–1122.

MARSTON, N. & L. R. ERTLE (1973) Host influence on the bionomics of *Trichogramma minutum*. *Ann. ent. Soc. Am.*, **66** : 1155–1162.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 255 *to* 257

PROTEIN CONTENT OF THE THORACIC MUSCLES OF THE RED COTTON BUG, *DYSDERCUS CINGULATUS* FABR. (PYRRHOCORIDAE : HETEROPTERA)

D. MURALEEDHARAN & V. K. K. PRABHU
Department of Zoology, University of Kerala, Kariavattom, Trivandrum
India 695581

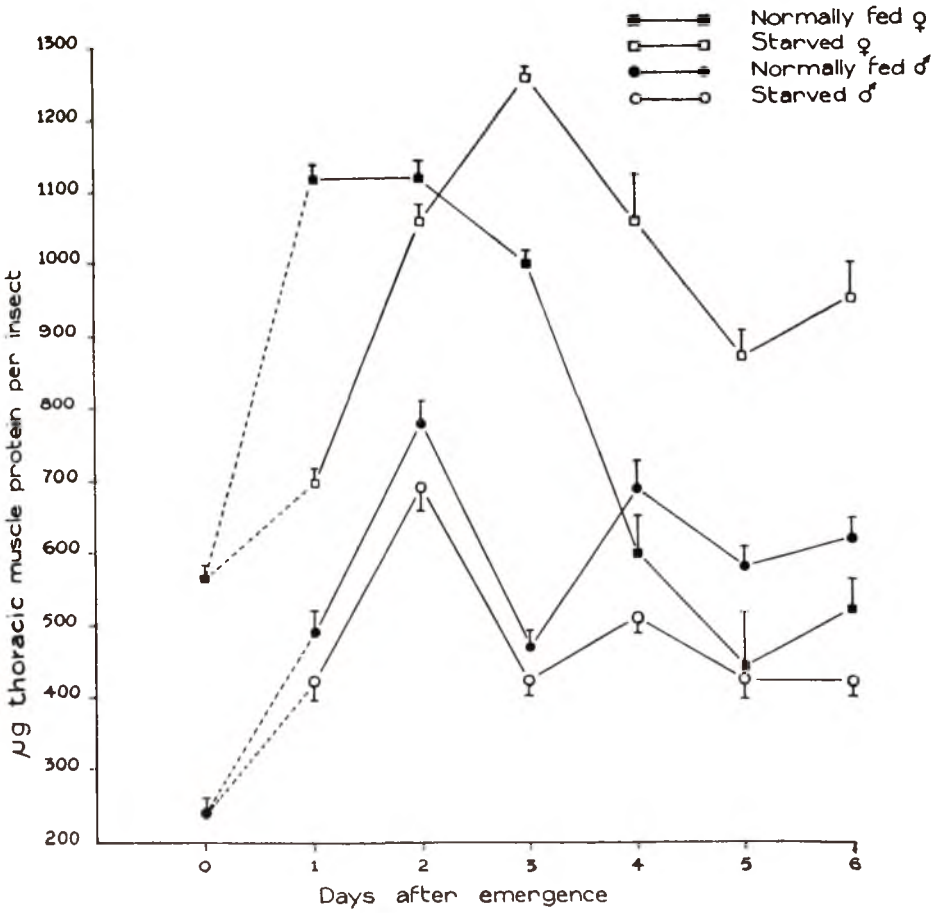
(*Received 10 August 1977*)

Protein content of the thoracic muscles of *Dysdercus cingulatus* during the first gonotrophic cycle decreases after day 2 in well-fed and starved males and females. The decrease is statistically more significant in the well-fed females than in the starved ones. There is no significant difference between the protein content of thoracic muscles of starved and well-fed males.

Cyclic degeneration and regeneration of flight muscles has been reported to coincide with reproductive cycle in many insects (CHAPMAN, 1957 ; BEDARD, 1968 ; BORDEN & SLATER, 1969 ; EDWARDS, 1969a; BHAKTHAN *et al.*, 1971). But in male insects flight muscles do not undergo degeneration to any great extent and in both the sexes starvation inhibits muscle atrophy (EDWARDS, 1969b; BHAKTHAN *et al.*, 1971). Degenerated muscle products are reported to escape into the haemolymph (SCHIMKE & DOYLE, 1970; GOLDBERG *et al.*, 1974; LOCKSHIN, 1975; LOCKSHIN & BEAULATION, 1974). The present study seeks to correlate the probable role, if any, of the proteins of the degenerating muscles in the reproductive activity in the bug, *Dysdercus cingulatus*.

Insects used for the present study were taken from the stock colony maintained in the laboratory on soaked cotton seeds. In the thoracic muscles of both sexes of *Dysdercus cingulatus*, total muscle proteins were estimated daily during the first six days of adult life (the females usually lay their first batch of eggs within six days) after allowing them to feed on soaked cotton seeds or alternatively, providing them distilled water only. Muscles from the dorsal thoracic region were dissected out in insect Ringer and homogenised in isotonic KCl solution. Proteins were precipitated with 10% trichloro acetic acid and centrifuged at 10,000 g for 20 minutes. The residue was dissolved in 0.1 N NaOH, so that 1 ml NaOH contained the proteins of the thoracic muscles of one insect. This served as the protein extract. Total protein was measured by the Folin-Ciocalteu phenol method (LOWRY *et al.*, 1951) using bovine albumin fraction V (Sigma Chemical Company, Missouri, U.S.A.) as the standard. Results were statistically analysed using STUDENT'S "t" test and are represented in Fig. 1.

As is evident from the figure, protein content of the muscle is very low in the newly emerged males and females while in the normally-fed insects, a steep increase can be noticed. Maximum protein content is found in one- and two-day old normally-fed females and two-day old, normally-fed males. Thereafter a steep decrease can be seen in the three-, four -and five-day old insects. The differences in the protein content of the thoracic muscles of three-, four-, five- and six-day old normally-fed females and that in the



Protein content in the degenerating thoracic muscle of the normally-fed and starved male and female insects of different age groups. Each point denotes the mean value of eight separate determinations and the vertical lines represent SEM.

starved ones of the corresponding age groups is statistically significant ($P < 0.05$). In *Dysdercus intermedius*, indirect flight muscles alternately degenerate and regenerate in relation to reproduction (EDWARDS, 1969a). Muscles may also involute and regrow as required during moulting and reproductive cycles (FINLAYSON, 1975). In the normally-fed *Dysdercus cingulatus*, vitellogenesis starts in the three-day old insects (JALAJA & PRABHU, 1971) and the oocytes are mature in the six-day old insects. In the same animal, a tremendous increase in the total protein content of the ovaries on days three, four and five has been demonstrated by PRABHU & NAYAR (1971). In the starved individuals egg maturation never takes place (unpublished observation). So the probable reason for the significantly higher levels of protein content in the thoracic muscles of four-, five- and-six day old starved females may be that proteins cannot be utilized for oocyte development in these insects. The differences between the protein content of the thoracic muscles of one-, two-, three-, four- and five-day old, normally-fed and starved

male insects are statistically insignificant. Since there is no need of vitellogenic proteins, no visible histolysis of muscles is noticed in the normally-fed male insects. But the significant daily fluctuation in the protein content of the thoracic muscles of the normally-fed as well as starved four-, five- and six-day old males, especially the sharp fall in protein content of thoracic muscles on day three is difficult to explain. On the whole, there is significantly less protein in the thoracic muscles in the male than in the female in this species. Dissections also show that the thoracic muscles of only normally-fed females (in which oocytes are developing) show visible histolytic changes. Hardly any signs of histolysis can be noticed in the starved females and in the normally-fed and starved males. In the two day old starved females, there is still more protein in the thoracic muscles apparently because there is no oocyte development to utilize the proteins. In the light of the present observations and the available literature, it appears that in *Dysdercus cingulatus,* proteins from the degenerating muscles are salvaged for vitellogenic functions in the female.

Acknowledgements:– The authors wish to thank Professor K. M. ALEXANDER for the facilities afforded in the Department.

REFERENCES

BEDARD, W. D. (1968) Additions to the knowledge of the biology of *Conophthorus lambertianae* HOPKINS (Coleoptera : Scolytidae). *Pan-Pacif. Ent.*, **44** : 7–17.

BHAKTHAN, N. M. G., K. K. NAIR & J. H. BORDEN (1971) Fine structure of degenerating flight muscles in a bark beetle, *Ips confusus*. II. Regeneration. *Can. J. Zool.*, **49** : 85–89.

BORDEN, J. H. & C. E. SLATER (1969) Flight muscle volume change in *Ips confusus* (Coleoptera : *Scolytidae*). *Can. J. Zool.*, **47** : 29–32.

CHAPMAN, J. A. (1957) Flight muscle change during adult life in the Scolytidae. *Can. Dept. Forestry Bi-mon. Progr. Rept.*, **13** (1) 3–4.

EDWARDS, P. J. (1969a) Development and histolysis of the indirect flight muscles in *Dysdercus intermedius*. *J. Insect Physiol.*, **15** : 1591–1599.

EDWARDS, F. J. (1969b) Environmental control of flight muscle histolysis in the bug, *Dysdercus intermedius*. *J. Insect Physiol.*, **15** : 2013–2020.

FINLAYSON, L. H. (1975) Development and degeneration : Aspects about muscle, 75–149, *in, Insect Muscle* (ed. USHERWOOD, P. N. R.), Academic Press, London, New York, San Fransisco.

GOLDBERG, A. L., E. M. HOWELL, J. B. LI, S. B. MARTEL & W. F. PROUTY (1974) Physiological significance of protein degradation in animal and bacterial cells. *Fedn Proc. Fedn. Am. Socs. exp. Biol.*, **33** : 1112–1120.

JALAJA, M. & V. K. K. PRABHU (1971) Blood protein concentration in relation to vitellogenesis in *Dysdercus cingulatus*. *Experientia*, **27** : 639–640.

LOCKSHIN, R. A. (1975) Degeneration of the intersegmental muscles : Alterations in haemolymph during muscle degeneration. *Devl Biol.*, **42** : 28–29.

LOCKSHIN, R. A. & J. BEAULATION (1974) Programmed cell death: Cytochemical appearance of lysosomes when the death of the intersegmental muscles is prevented. *J. Ultrastruct. Res.*, **46** : 63–78.

LOWRY, O. H., N. J. ROSENBAUM, A. L. FARR & R. J. RANDALL (1951) Protein measurement with the Folin-Phenol reagent. *J. biol. Chem.*, **193** : 265–268.

PRABHU, V. K. K. & K. K. NAYAR (1971) Protein and free amino acid concentration in the blood and total ovarian proteins in *Dysdercus cingulatus* FABR. (Heteroptera) during reproduction. *Comp. Biochem. Physiol.*, **40B** : 515–519.

SCHIMKO, R. T. & D. DOYLE (1970) Control of enzyme levels in animal tissues. *A. Rev. Biochem.*, **39** : 929–976.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 259 *to* 261

JUVENOMIMETIC ACTIVITY IN SOME SOUTH INDIAN PLANTS AND THE PROBABLE CAUSE OF THIS ACTIVITY IN *MORUS ALBA*

B. GOPAKUMAR, B. AMBIKA & V. K. K. PRABHU
Departemnt of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695581

(*Received 10 August 1977*)

All the twelve plants investigated were found to contain different degrees of juvenomimetic activity; experiments using *Morus alba* extract tended to show that this activity was due to JH analogues present in the plant.

It has been reported from this laboratory that acetone extracts of many South Indian plants show juvenile hormone (JH) like activity when applied topically to the early stage of last instar nymphs of *Dysdercus cingulatus* (PRABHU *et al.*, 1973; PRABHU & JOHN, 1975a, b). The conclusion has been reached on the basis of the principles on which most JH bioassays are based, namely, JH analogues tend to retain juvenile characters in the animal after subsequent moult, when topically applied to the last immature instar prior to critical period. However, it has been pointed out that the exogenous substances might be acting on the animal through its own corpus allatum or at least that it might be synergistic with the animal's intrinsic JH (SLADE & WILKINSON, 1973). The present paper summarises the results of screening of some additional plants for juvenomimetic activity and the probable cause of this activity in the plant extracts.

Insects were reared and maintained in the laboratory as already reported (JALAJA & PRABHU, 1976 a). Acetone extract of dried stem of the plants was assayed for JH activity as reported earlier (PRABHU *et al.*, 1973) using *Dysdercus cingulatus* as the assay animal. Newly moulted adult females were allatectomised as previously reported (JALAJA & PRABHU, 1976 b) and *Morus alba* extract was applied either on the same day (single dose of 8 FME equivalents, PRABHU *et al.*, 1973) or on 3rd, 4th and 5th days (three similar doses) after the operation. Allatectomised control animals were treated with acetone only. Animals were sacrificed six days after allatectomy. The ovaries were fixed in Bouin's fluid and cut and stained in the routine way. Allatectomy was confirmed by dissection at the time of sacrifice and ovaries from those animals from which allatectomy was incomplete, were discarded. Data from at least ten animals was available for analysis.

It has been observed that all the twelve plants screened for juvenomimetic activity are positive for the bioassay and their activity is shown as FME values (PRABHU *et al.*, 1973) in parentheses. These plants are: *Vitis vinifera* (367 FME eqs), *Santalum album* (184 FME eqs), *Morus alba* (102 FME eqs), *Cocos nucifera* (61 FME eqs), *Morinda tinctoria* (61 FME eqs), *Nyctanthus arbor* (61 FME eqs), *Acalypha hispida* (61 FME eqs), *Bauhinia acuminata* (61 FME eqs), *Bougainvilla glabra* (31FME eqs), *Malvaviscus populinus* (31 FME eqs), *Hibiscus rosasinensis* (20 FME eqs) and *Anacardium occidentale* (20 FME eqs). In the ovaries of allatectomised control insects (Fig. 2)

there was no yolk deposition; the oocytes were small and the structure of the ovaries was comparable to that described by JALAJA & PRABHU (1976b, 1977). On the other hand, the ovaries of allatectomised insects to which single dose of *Morus alba* extract was applied on the day of operation, showed some yolk deposition when examined sixth day after treatment (Fig. 1). In the ovaries of allatectomised animals to which three doses of *Morus alba* extract were applied on days 3, 4 and 5 after the operation, yolk deposition was heavy (Figs. 3 and 4).

Present findings show that all the twelve additional plants screened show juvenomimetic activity. Experimental studies involving allatectomy followed by topical application of the *Morus alba* extract shows that the effect of the plant extract was not mediated through the animal's corpus allatum. It has already been reported that the extract of *Tectona grandis* when applied to allatectomised *D. cingulatus* stimulates some yolk deposition in the oocytes (PRABHU, 1977). The effect of application of a single dose on the day of operation is evidently less than three doses applied on days 3, 4 and 5. It is clear that these effects are not mediated through the host's corpus allatum; the effects are likely to be due to the JH analogues contained in the plant extract rather than due to synergism (STAAL, 1975).

Acknowledgements:– We thank Prof. K.M. ALEXANDER for facilities afforded, and to Dr. P.N. CHANDRASEKHARAN NAIR, Department of Botany, University of Kerala, for identifying the plants. V. K. K. P. thanks the UGC for a research grant

REFERENCES

JALAJA, M. & V. K. K. PRABHU (1976a) Effects of chemosterilants apholate and metepa on the ovaries of the red cotton bug *Dysdercus cingulatus* FABR. (Insecta, Heteroptera, Pyrrhocoridae). *Entomon*, **1** : 43–53.

JALAJA, M. & V. K. K. PRABHU (1976b) Inhibition of vitellogenesis by allatectomy in the red cotton bug, *Dysdercus cingulatus* FABR. (Insecta, Heteroptera, Pyrrhocoridae). *Entomon*, **1** : 193-194.

JALAJA, M. & V. K. K. PRABHU (1977) Endocrine control of vitellogenesis in the red cotton bug *Dysdercus cingulatus* FABR. (Heteroptera, Pyrrhocoridae). *Entomon*, **2** : 17–19.

PRABHU, V. K. K. (1977) Insect juvenile hormone in plants and the problem of host-specificity in insects, 69–74, *in*: *Insects and Host Specificity* (ed. T. N. ANANTHAKRISHNAN), Macmillan, India.

PRABHU, V. K. K. & M. JOHN (1975a) Juvenomimetic activity in some plants. *Experientia*, **31**: 913–914.

PRABHU, V. K. K. & M. JOHN (1975b) Ovarian development in juvenilised adult *Dysdercus cingulatus* affected by some plant extracts. *Entomologia exp. appl.*, **18**: 87–95.

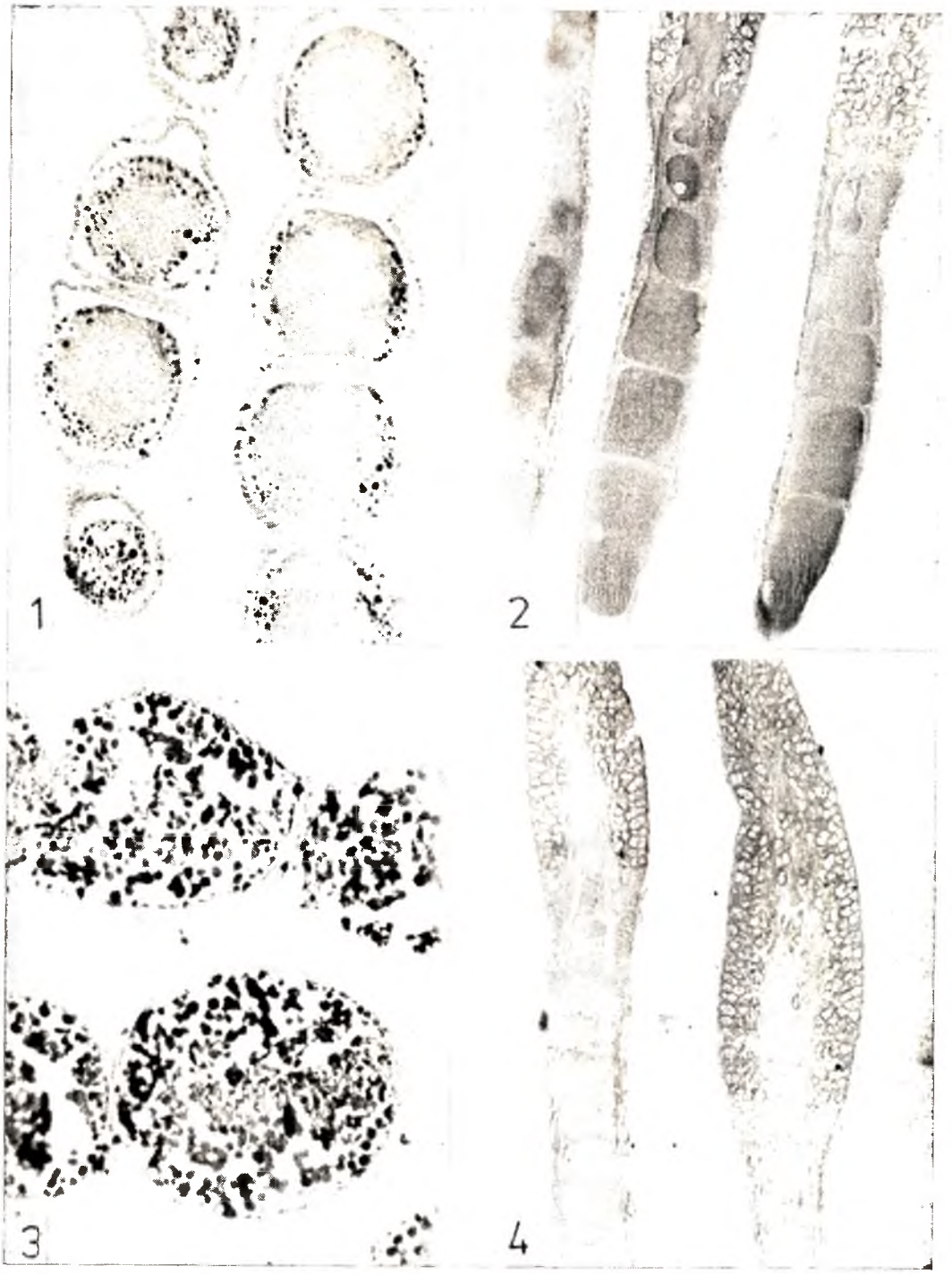
PRABHU, V. K. K, M. JOHN & B. AMBIKA (1973) Juvenile hormone activity in some South Indian plants. *Curr. Sci.*, **42** : 725–726.

SLADE, M. & C. F. WILKINSON (1973) Juvenile hormone analogues: a possible case of mistaken identity? *Science*, **181** : 672–674.

STAAL, G. B. (1975) Insect growth regulators with juvenile hormone activity. *A. Rev. Ent.*, **20**: 417–460.

EXPLANATION OF FIGURES

Figs. 1 & 2. Sections of ovaries six days after application of single dose of *Morus alba* extract to allatectomised animal, and its control respecively. Extract was applied on the day of allatectomy. Note the larger oocytes in the experimental animal, with distinct yolk granules at the periphery. Figs. 3 & 4. Sections of ovarioles of allatectomised animals to which three doses of *Morus alba* extract were applied on 3rd, 4th and 5th days after the operation, and its control respectively. Note the larger, heavily yolked oocytes in the experimental animal. Also note that the differences are more conspicuous after multiple treatmnt. All sections are of Bouni fixed tissue and stained with haematoxylin eosin; × 90.


1
2
3
4

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 263 *to* 267

CHANGES IN THE PROTHORACIC GLANDS OF *DYSDERCUS CINGULATUS* FABR. (HETEROPTERA, PYRRHOCORIDAE) DURING ADULT LIFE

ALEYAMMA JOSEPH & V. K. K. PRABHU
Department of Zoology, University of Kerala, Kariavattom,
Trivandrum, India 695581

(*Received 10 August 1977*)

In adult *Dysdercus cingulatus* prothoracic glands can be traced upto twenty days. Cell size and nuclear size decrease with age and cytoplasmic granules increase in number. The glands appear to be inactive in the adult. Active nymphal prothoracic glands inhibit vitellogenesis.

In vitro studies have shown that in insects prothoracic glands produce α-ecdysone, which gets converted to β- ecdysone stimulating moulting (SCHNEIDERMAN & GILBERT, 1964; WIGGLESWORTH 1970; KAMBYSELLIS & WILLIAMS, 1972; BROST & ENGELMANN, 1974; KING & MARKS, 1974; CHINO *et al.*, 1974). After adult ecdysis prothoracic glands are reported to disintegrate (WELLS, 1954; HERMANN, 1967; MALA *et al.*, 1974). Prothoracic glands are reported to be difficult to detect two days after adult ecdysis in *Dysdercus cingulatus* (WELLS, 1974). However, in this animal we have traced prothoracic glands upto twenty days in the adult and the present paper embodies these findings.

Insects were reared in the laboratory as already reported (JALAJA & PRABHU, 1976). All the animals employed for the present study were of known age. A calibrated ocular micrometer in a phase contrast microscope was used for taking measurements on prothoracic glands. The cell volume was calculated using the formula $4/3\ \pi\ r^3$ or $4/3\ \pi\ ab^2$ (PENZLIN, 1971) depending upon whether the cells were spherical or oval. For implantation, prothoracic glands from 4-day old fifth instar nymphs were employed. The usual sterilization procedures were followed (JALAJA *et al.*, 1973). Three pairs of prothoracic glands were introduced into the abdomen of newly moulted adult females through a slit made on the ventral side. Animals in which fat bodies were implanted served as controls. The ovaries were dissected out five days after implantation and were fixed in 10% formalin and processed for histological studies.

Prothoracic glands of newly moulted adult: Prothoracic glands are concealed beneath fat bodies and are diffusely arranged among tracheae, extending between the corpus allatum and the posterior end of the salivary glands (Fig. 1). Each gland consists of about 200 cells. They are innervated from the thoracic ganglion. Almost all the cells of the newly emerged adult are spherical and transparent, having a diameter of about 65μ with a nucleus of 16 μ. Vacuoles are also noticed in the cytoplasm (Fig. 2).

Changes during adult life: With age, cells lose their transparent nature. Shape of the cells changes to ellipsoid. Granules in the cytoplasm increase in number. Within

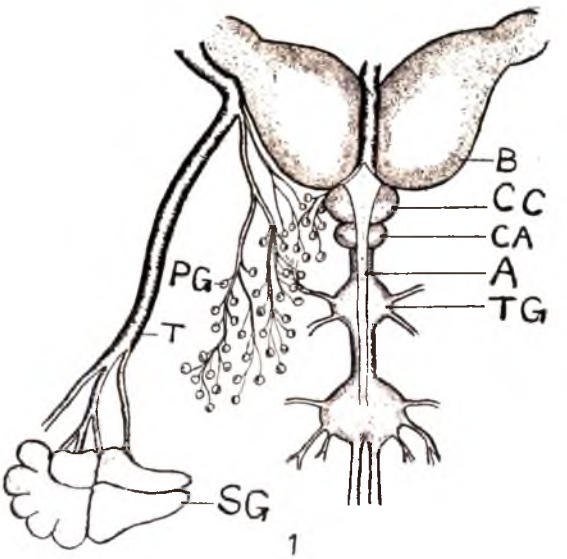
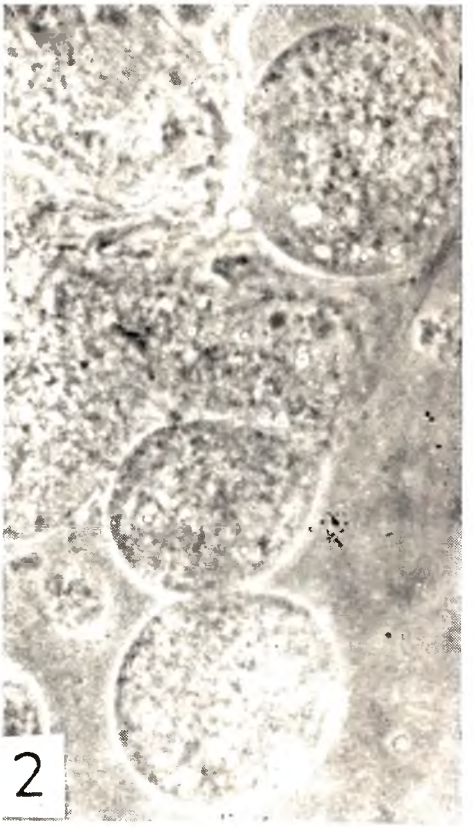


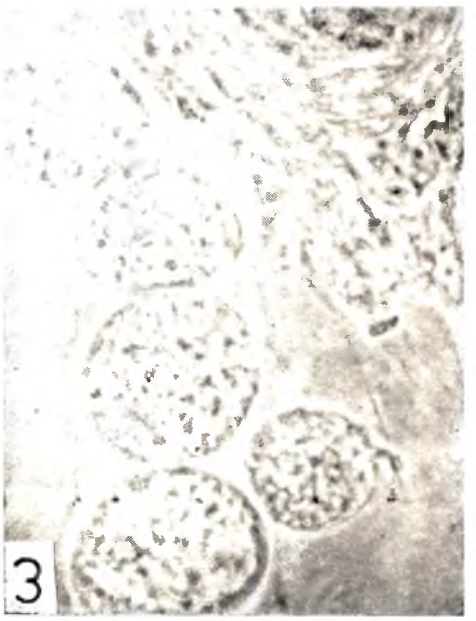
Fig. 1. Arrangement of prothoracic glands (left). A–aorta; B–brain; CA–cropus allatum; CC–corpus cardiacum; PG–prothoracic gland cell; SG–salivary gland; C–thoracic ganglion.

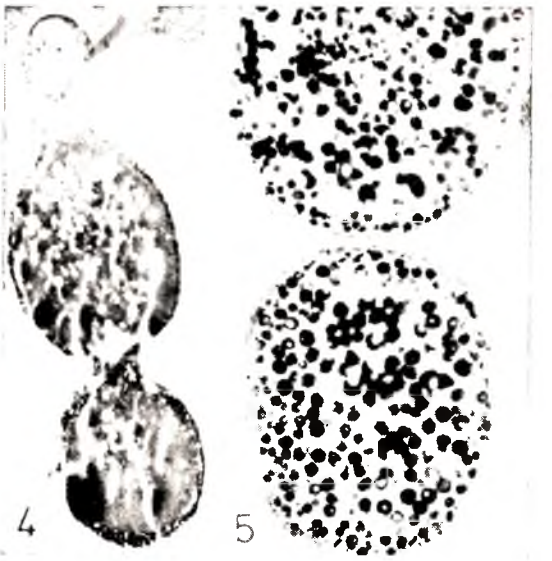
twenty days of adult life the gland cell decreases from 150,00μ^3 to 30,000μ^3 (Fig. 3).

Effect of implantation of prothoracic glands on the ovaries: In the experimental animals on the fifth day after implantation of prothoracic glands, oocytes are poorly developed when compared to the controls (Figs. 4 and 5). The yolk granules are fewer and smaller. This difference is more conspicuous in the basalmost oocyte. Oocytes in the control insects are comparable to those of the five day old normal adults (JALAJA *et al.*, 1976).

In morphological appearance the prothoracic glands of *Dysdercus cingulatus* are comparable to those of *Rhodnius prolixus* (WIGGLE SWORTH, 1952) and in *Iphita limbata* (NAYAR, 1953), in their being made of loosely arranged cells, whereas according to WELLS (1954) the glands of *D.cingulatus* are compact. The present studies have shown that prothoracic glands in adult *Dysdercus cingulatus* can be seen upto 20 days unlike what has been reported by WELLS (1954). In *Hyalophora cecropia* and in *Memestra brasisica* (HERMAN & GILBERT, 1966; AGUI, 1975), older prothoracic glands contain more ellipsoid cells than spherical ones. The charateristic features of active prothoracic glands such as well defined nucleus, vacuoles etc. (HERMAN & GILBERT, 1966; HERMAN, 1967; MALA *et al.*, 1974; MC DANIEL *et al.*, 1976) have been noticed in the fifth instar nymphs of *D. cingulatus* (unpublished data). Based on cytoplasmic criteria and experimental results involving implantation of the glands, it appears that in *D. cingulatus* the prothoracic glands are inactive. Active nymphal prothoracic glands have however an inhibitory action on vitellogenesis when implanted into adults. Structure of the ovaries after implanation of prothoracic glands is comparable to that obtained after ecdysone administration by JALAJA *et al.* (1976). This is apparently because the implanted nymphal glands are producing enough ecdysone to inhibit the development of the adult ovaries.







Figs. 2 & 3. Prothoracic gland cells of the newly moulted adult female and those of twenty days after adult emergence respectively, phase contrast. × 400.

Figs. 4 & 5. Section of the ovariole five days after implantation of three pairs of active nymphal prothoracic glands into newly moulted adult female and its control respectively. Formalin, haematoxylin eosin, × 80.

Acknowledgements:– We are indebted to Dr. T. N. Ananthakrishnan, Director, ZSI, Calcutta and to Dr. Bimal Datt, ZSI, for confirming the identification of the animal, and Prof. K.M. Alexander for facilities afforded. A. J. also acknowldeges the receipt of a research fellowship from the University of Kerala during which period the present work was carried out.

REFERENCES

Agui, N. (1975) Activation of prothoracic glands by brains *in vitro*. *J. Insect Physiol.*, **21**: 903–915.

Brost, D. W. & F. Engelmann (1974) *In vitro* secretion of ecdysone by prothoracic glands of a hemimetabolous insect, *Leucophaea maderae* (Balttaria). *J. exp. Zool.*, **189** : 413–419.

Chino, H., S. Sakuri, T. Ohtaki, H. Ihekawa, M. Ihirashi & H. Abuki (1974) Biosynthesis of ecdysone by the prothoracic glands *in vitro*. *Science*, **183** : 529–530.

Herman, W. S. (1967) Ecdysial glands of arthropods. *Int. Rev. Cytol.*, **22** : 269–347.

Herman, W. S. & L. I. Gilbert (1966) The neuroendocrine system of *Hyalophora cecropia* (Lepidoptera : Saturniidae). I. The anatomy and histology of the ecdysial gland. *Gen. Comp Endocrinol.*, **7** : 275–291.

Jalaja, M & V. K. K. Prabhu (1976) Effect of the chemosterilants apholate and metepa on the ovaries of the red cotton bug, *Dysdercus cingulatus* Fabr. (Insecta, Heteroptera, Pyrrhocoridae). *Entomon*, **1** : 43–53.

Jalaja, M., D. Muraleedharan & V.K.K. Prabhu (1973) Effect of extirpation of median neurosecretory cells on reproduction in the female red cotton bug, *Dysdercus cingulatus*. *J. Insect Physiol.*, **19** : 29–36.

Jalaja, M., G. C. Unnithan & V. K. K. Prabhu (1976) Ecdysterone induced ovarian inhibition in the red cotton bug *Dysdercus cingulatus*. *Curr. Sci.*, **45** : 621–622.

Kambysellis, M. P. & C. M. Williams (1972) Spermatogenesis in cultured testes of the cynthia silk worm. Effect of ecdysone and prothoracic glands. *Science*, **175** : 769–770.

King, D. S. & E. P. Marks (1974) The secretion and metabolism of ∝– ecdysone by cockroach (*Leucophaea maderae*) tissues *in vitro*. *Life Sci.*, **15** : 147–154.

Mala, J., V. J. A. Novak, I. Bzlsek & A. Balazs (1974) The effect of juvenile hormone on prothorcic glands in *Galleria mellonella*. I. Morphology of the glands in the course of postembryonic development. *Acta Biol. hung.*, **5**: 85–95.

McDaniel, C. N., E. Johnson, T. Saum & S. J. Berry (1976) Ultrastructure of active and inhibited prothoracic glands. *J. Insect Physiol.*, **22** :

Nayar, K. K. (1953) Thoracic glands of *Iphita limbata* Stal. *Nature*, **172**: 768.

Penzlin, H. (1971) The effect of neurohormone D upon the nuclear volume of the prothoracic gland in *Periplaneta americana* L. (Blattaria), 99-103, *in* : *Insect Endorcrines* (ed. Novak, V.J.A. & K. Slama), Academia Prahha.

Schneiderman, H. A. & L. I. Gilbert (1964) Control of growth and development in insects. **143** : 425–333.

Wells, S. B. (1954) The thoracic glands of Hemiptera and Heteroptera (*Dysdercus cingulatus*). *Q. Jl. microsc. Sci.*, **95**: 231–244.

Wigglesworth, V. B. (1952) The thoracic glands in *Rhodnius prolixus* (Hemiptera) and its role in moulting. *J. exp. Biol.*, **18**: 661–665.

Wigglesworth, V. B. (1970) *Insect Hormones*. Oliver and Boyd, Edinburgh, 159 pp.

Entomon, 1977, *Vol.* 2, *No.* 2, *pp.* 269 *to* 270

BOOK REVIEW

INDIAN JOURNAL OF ACAROLOGY, Published by the Acarological Society of India, University of Agricultural Sciences, Bangalore 560024, 1976, Vol. I, Number 1 & 2, pp. 1–56. Rs. 20.00/$ 10.00.

The laudable venture of the Acarological Society of India in starting the publication of the *Indian Journal of Acarology*, a half yearly journal, wholly devoted to the publication of original findings on mites and ticks merits the attention of acarologists in India and abroad. A large number of papers are published every year on diverse aspects of this ubiquitous group. At the international level there are only a few journals now devoted solely to acarines and they are quite inadequate in satisfying the needs of all the researchers on this group, with the result that publications on acarines appear in journals of a wide variety. Publication of journals serving the interests of specialized areas and at a low cost would greatly encourage individual subscribers and bring information quickly and readily to a larger section of researchers.

The birth of the *Indian Journal of Acarology* should be welcomed in this context. The journal accepts original publications on all aspects of study of Acarina like taxonomy, ecology, biology, zoogeography, control and relationship. The first volume of the journal however, is a collection of eight papers on the taxonomic aspects of mites. One would feel that a wider selection of articles is imperative for realising the objectives of the Society and also for evincing greater interest in the journal from acarologists and nonacarologists as well. Perhaps taxonomy is still the major concern of the students of mites and ticks in India. The general getup of the journal is good although some of the figures have not come up as well as they should. The journal is reasonably priced and is well within the means of the individual subscribers. Efforts should be made to bring out the journal in time.

N. R. PRABHOO

TAXONOMY OF THE BRUCHIDAE (COLEOPTERA) OF NORTHWEST INDIA, PART–I. ADULTS, by G. L. ARORA, Oriental Insects Supplement No. 7, The Association for the study of Oriental Insects, University of Delhi, Delhi–7, 1977, 132 pp. Rs. 60.00/$ 10.00

The Association for the study of Oriental Insects is making commendable efforts to assist Entomologists all over the world by bringing out monographs on particular groups of insects. The present monograph on Bruchidae, written by G. L. ARORA, a well known authority on the group, is the latest in this series. Generallly known as the bean beetles, the bruchids have "long been reported to destroy the seeds of leguminous plants, but a number of them are now known also to attack the seeds or associated with the flowers or leaves of plants" belonging to several other families. In a country like India with a diversity of flora characteristic of the tropics, the importance of the study of bruchids can hardly be overemphasized. With many parts of India still remaining unexplored or poorly explored the gap in our knowledge of the Indian bruchids could be filled only if more persons could be attracted to the study of this group. This profusely illustrated monograph with 338 line drawings in 48 plates and 66 photographs providing detailed descriptions of 48 species will contribute very much in introducing new workers in this field. The

monograph also contains keys to subfamilies, genera and species dealt with in the study. There is a table giving the list of hosts and distribution in India of all the 48 species. Sexually dimorphic features of these species are given in another table. The author could have given some information on the world distribution of the 23 species which are already known.

N. R. PRABHOO

PROF. EICHLER'S PARASITOLOGISCH-INSEKTIZIDKUNDLICHES WOERTERBUCH, veb Gustav Fischer Verlag, Jena, 1977: 525 pp., Price (Inland) DDR 29 M, (Other Countries) DDR 39 M.

Prof. Wd. EICHLER's publication "Parasitologisch – insektizidkundliches Wörterbuch" (a glossary of terms used in parasitology, medicine, and insecticide industry) is a valuable addition to our parasitological literature.

The glossary includes 5886 serially numbered and alphabetically arranged German terminologies (both scientific and vernacular) used in parasitology, medicine, biochemistry, toxicology, and insecticide industry, followed by the English and Russian equivalents. Meanings of terms are given in German. Separate indices for English, Russian, and scientific terms used in this work are also provided. The difficulty in translating German parasitological works is often keenly felt by those not familiar with that language and this glossary will undoubtedly serve as a ready reckoner in future.

Prof. EICHLER with his nearly half a century experience in the fields of parasitology and applied entomology, together with his well known collaborators Dr. M. J.ASS, H. BEITZ, V. BOZDECH, J. JIRA, and Prof. K. ODENING, deserve all congratulations for bringing out such a useful compilation. The value of this work would have greatly enhanced, had the German explanation of the terms been also given in the other two languages, and it is hoped that the author and the publishers will fill the lacuna in future editions.

K. V. LAKSHMINARAYANA

Reg. No. R. N. 29386 / 76

Covered by international
indexing and abstracting journals

Printed by V. K. K. Prabhu at St. Joseph's Press,
Trivandrum for the Association for Advancement of Entomology.

INFORMATION TO CONTRIBUTORS

General : ENTOMON will accept original articles arising from studies on insects and other land arthropods. Material submitted for publication in the journal should not have been published or submitted for publication elsewhere. Manuscripts in duplicate, including figures, must be sent by Registered Mail to the *Managing Editor, ENTOMON, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695581.*

Articles should be in English only and may be either *Brief Communications* not exceeding two printed pages, or *Papers* normally not exceeding ten printed pages. The authors should consult a recent issue of the journal and follow the style closely.

Text : Papers may, as far as possible, be organised as under: Abstract, Introduction, Material and Methods, Results, Discussion, Acknowledgements, References, Legend, Tables and Foot-notes. All pages should be numbered serially. Brief communications need not have the above format.

Articles should be neatly type written double spaced, including References, Legend, Tables etc., on one side only of good quality bond paper, leaving sufficient margin.

Foot notes should be avoided as far as possible. When included they should be given on a separate sheet. In the text, reference to foot notes should be indicated by superscript numerals.

Tables should be numbered in Arabic numerals, and should be given on sheets separate from the text. The approximate position of tables in the text should be indicated in the left margin and cirled.

Illustrations should accompany the script separately. The short title of the article, the name of the author (s) and figure number should be indicated on the reverse side of the illustrations. Legend should be typed on sheets separate from the text. Line drawings and photographs should be consecutively numbered together in Arabic numerals without distinction between drawings and photographs. Photographs should be organised and mounted in the form of plates. The approximate position of the illustrations in the text should be indicated in the left margin and circled. Blocks up to an equivalent of one full page size are allowed free of cost. However additional blocks will be fully charged for. Authors are advised to carefully plan their illustration so as to occupy minimum space and permit sufficient reduction. This is in the interest of the authors as well as the journal.

Use only **metric units** as far as possible. Abbreviations of units should not be followed by full stop unless to avoid confusion.

References should be cited in the text by name(s) of author(s) and year of publication as: NAYAR (1958), or (NAYAR, 1958), NAYAR *et al.* (1970) etc. Abbreviate titles of periodicals according to *World List of Scientific Periodicals*, 4th ed., Butterworth, London (1963). The following style should be used for listing references:

Articles in journals: NAYAR, K. K. (1958) Studies on the neurosecretory system of *Iphita*. V. Endocrine basis of oviposition in female. *Proc. Indian Acad. Sci.*, **47B**: 233–251.

NAYAR, K. K., M. BALLS & E. ARTHUR (1970) Transmission of amphibian lymphosarcoma to and through insects. *Oncology*, **24**: 370–377.

Books: NAYAR, K.K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56pp. *Chapter in a book compiled and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 249–370, *in: The Physiology of Insecta*, Vol. **1**, 2nd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

Reprints: No gratis reprints will be supplied. The number of reprints required should be specified as soon as the paper is accepted for publication in the journal. Table showing the cost of reprints will be supplied to authors when acceptance of the paper is communicated.

Editors reserve the right to revise the wording of manuscripts accepted for publication. The authors are solely responsible for the views expressed in their articles.